Fugitive Emission Calculations for WARP at 11A Pipestill

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	5	0.5789	0.0013	2.0%	0.0643	95%	100%	0.01
Light Liquid	90	0.1878	0.0037	2.0%	0.6644	95%	100%	0.15
Heavy Liquid	7	0.00051	0.00051	2.0%	0.0036	30%	100%	0.01
Pumps								
Light Liquid	1	0.9630	0.0265	2.0%	0.0452	80%	100%	0.04
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	15	0.0827	0.00013	0.3%	0.0057	30%	100%	0.02
Light Liquid	163	0.0827	0.00013	0.3%	0.0616	30%	100%	0.19
Heavy Liquid	12	0.0827	0.00013	0.3%	0.0045	30%	100%	0.01
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves - Added[3]	1	3.728	0.0985	2.0%	0.1711	98%	100%	0.01
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
Total VOC Emissions Associated with Added Components (tons/yr):								0.45

Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	-23	0.1878	0.0037	2.0%	-0.1698	95%	100%	-0.04
Heavy Liquid	-8	0.00051	0.00051	2.0%	-0.0041	30%	100%	-0.01
Flanges								
Gas/Vapor	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Light Liquid	-46	0.0827	0.00013	0.3%	-0.0174	30%	100%	-0.05
Heavy Liquid	-19	0.0827	0.00013	0.3%	-0.0072	30%	100%	-0.02
Total VOC Emissions Associated with Removed Components (tons/yr):								**-0.12**

Past Emissions from Relief Valves - Existing Controlled[3]	47	3.728	0.0985	2.0%	8.0412	90%	100%	3.52
Relief Valves - Existing Controlled[3]	47	3.728	0.0985	2.0%	8.0412	98%	100%	0.70
Emissions Reduction (Future - Past)								-2.82
Total VOC Emissions Associated with Added Components and Additional Controls (tons/yr):								**-2.50**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

[3] There is 1 new relief valve and 47 existing RV's - previously routed to the atmosphere (through the blowdown stack) that are now routed to the DDU flare. The existing RVs were previously controlled with a water spray chamber that is presumed to be capable of 90% control.

Increased Sewer Emissions from 11A WARP Project due to Added Equipment

EQUIPMENT TYPE	UNIT 11A PS - Estimated Counts	
Atmospheric Drain Hub	15	
Catch Basin (Pad or Paving Drain)	6	
Inspection Points	7	
Cleanouts	6	
Above Ground Sewer Pump Out Points		
Sum of Drains	**34**	*Does Not include Above ground pump out lines as are typically fugitive emissions included with fugitives*
Manhole/Junction Box w/o Vent		
Manhole/Junction Box w/ CC and/or Vent		
OSBL Manholes Per Unit - Sealed		
Flare / Degassing/ KO Tanks (ie Above Ground Junction Boxes)	0	
Sealed cover sumps - Gas Traps or other sumps		
Total Manholes/Junction Boxes/Sealed Sumps	**0**	
Below Grade Oily Water Separator - Fixed Roof		
Below Grade Oily Water Separator - Floating Roof		
OSBL Sumps/OWS Per Unit		
Total In ground OWS/Sumps	**0**	
Tanks DGO / LGO / Sour Water service		
Above Ground Oil Water Separator Tanks		
Total Above Ground Tanks	**0**	

Assumptions:
All units will meet Benzene Neshaps Compliance Standards
No COV's will be utilized

AP-42 Factors - Section 5-1 Petroleum Refining 1/95 - Calculations assume 50% control on drains versus uncontrolled drain emissions in AP-42		No. of Units	Units of 1000 liters of flow	Emission Factor Value	Emission Factor Units	Total Emissions (kg/hr)
EMISSION INCREASES						
Drains Controlled		34		0.3	kg/day/unit	0.49
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)		0		0.03	kg/day/unit	0.00
Sealed Manholes		0		0.16	kg/day/unit	0.00
Oil Water Separator and Auxillaries						
	OWS	0		0.024	**kg/1000 liters flow**	0.000
	Slop oil tanks/OW surge tanks				Use Tanks Program	0.00
	OWS Abv Gr (API) Controlled	0		0.024	**kg/1000 liters flow**	0.000
Subtotal for Emission Increases						0.49

EMISSION DECREASES				
Area Drains Controlled	0.3	kg/day/unit		0.00
Area Drains Uncontrolled	0.7	kg/day/unit		0.00
Process Drains Controlled	0.3	kg/day/unit		0.00
Process Drains Uncontrolled	0.7	kg/day/unit		0.00
Catch Basins Controlled	0.3	kg/day/unit		0.00
Catch Basins Uncontrolled	0.7	kg/day/unit		0.00
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)	0.03	kg/day/unit		0.00
Sealed Manholes	0.16	kg/day/unit		0.00
Junction Boxes/Manholes Uncontrolled	0.7	kg/day/unit		0.00
Oil Water Separator and Auxillaries				
OWS (API) Controlled	0.024	kg/1000 liters		0.00
OWS (API) Uncontrolled	0.6	kg/1000 liters		0.00
Slop oil tanks/OW surge tanks				0.00
OWS Abv Gr (API) UnControlled	0.6	kg/1000 liters		0.00
OWS Abv Gr (API) Controlled	0.024	kg/1000 liters		0.00

Subtotal for Emission Decreases	0.00

NET EMISSIONS

kg/hr	0.49
lb/d	25.89
lb/yr	9451
TPY	**4.7**

Notes:

Emission Source		Units	Source*
Uncontrolled Drain	0.69	Kg/day	AP-42 (e.g. 450/650)
Controlled Drain (with water trap – 50% control of AP-42)	0.0145	Kg/hr	BIDa
Sealed Manway Cover (gasketed – 77% of AP-42)	0.022	Kg/hr	BIDb
Uncontrolled Junction Box (same as an Uncontrolled Drain)	0.029	Kg/hr	AP-42 (ref. BIDa)
Controlled Junction Box (with carbon canister to comply with BWON – 5% of AP-42)	0.00145	Kg/hr	BIDa, BWON
Uncontrolled OWS	0.6	Kg/1000 liters	AP-42
Controlled OWS	0.024	Kg/1000 liters	AP-42

*Notes:
BIDa - Background Information Document to Proposed NSPS QQQ, Feb. 1985.
BIDb - Background Information Document to Proposed NSPS QQQ, Dec. 1987.
AP-42 - AP 42, Fifth Edition, Volume I Chapter 5.1 Petroleum Refining, Jan. 1995.

11A Emergency Relief Valves to the DDU Flare

Process Unit	Malfunction Rates		HHV	Sulfur	Frequency	Duration	VOC				NO_X				SO_2				PM				$PM_{10}/PM_{2.5}$				CO				Pb				Hg				Be			
			BTU/scf	ppm	#/year	hours	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/day[1]	tpy	EF	Unit	lb/day[1]	tpy
AZ-29	0.2466	MMscfh	4,420	1,000	2.0	0.33					0.068	lb/MMBtu	24.7	0.02	see below[2]		13.7	0.01	1.9	lb/MMscf	0.68	0.00	7.6	lb/MMscf	2.71	0.00	0.37	lb/MMBtu	134.4	0.13	5.0E-04	lb/MMscf	1.8E-04	1.78E-07	1.84E-04	lb/MMscf	6.5E-05	6.54E-08	1.20E-05	lb/MMscf	4.3E-06	4.27E-09
AZ-509	0.0356	MMscfh	4,000	150,000	1.0	0.33					0.068	lb/MMBtu	3.2	0.00	see below[2]		295.8	0.15	1.9	lb/MMscf	0.09	0.00	7.6	lb/MMscf	0.35	0.00	0.37	lb/MMBtu	17.6	0.01	5.0E-04	lb/MMscf	2.3E-05	1.16E-08	1.84E-04	lb/MMscf	8.5E-06	4.27E-09	1.20E-05	lb/MMscf	5.6E-07	2.79E-10
AZ-575/AZ-578	0.8331	MMscfh	5,060	1,000	1.0	0.33					0.068	lb/MMBtu	95.6	0.05	see below[2]		46.1	0.02	1.9	lb/MMscf	2.62	0.00	7.6	lb/MMscf	10.47	0.01	0.37	lb/MMBtu	519.9	0.26	5.0E-04	lb/MMscf	6.9E-04	3.44E-07	1.84E-04	lb/MMscf	2.5E-04	1.26E-07	1.20E-05	lb/MMscf	1.7E-05	8.27E-09
AZ-0589	0.1362	MMscfh	1,300	30,000	1.0	0.33					0.068	lb/MMBtu	4.0	0.00	see below[2]		226.3	0.11	1.9	lb/MMscf	0.11	0.00	7.6	lb/MMscf	0.44	0.00	0.37	lb/MMBtu	21.8	0.01	5.0E-04	lb/MMscf	2.9E-05	1.45E-08	1.84E-04	lb/MMscf	1.1E-05	5.31E-09	1.20E-05	lb/MMscf	6.9E-07	3.47E-10

	VOC[3]		NO_X		SO_2		PM		$PM_{10}/PM_{2.5}$		CO		Pb		Hg		Be	
Total Projected Actual Emissions				7.6E-02		0.30		2.1E-03		8.3E-03		0.41		5.5E-07		2.0E-07		1.3E-08
Major New Source Review Thresholds		40		40		40		25		15		100		0.6		0.1		0.1
Major New Source Review Triggered?		No		No		No		No		No		No		No		No		No

[1] Event emission rate represents one worst case emergency/malfunction scenario event. Annual emission rate represents the estimated annual average total duration of worst case emergency/malfunction events.

[2] SO_2 Emissions Calculation:

SO2 MW (lb/lb-mole)=		64

SO2 emissions are calculated based on the concentration of sulfur in the gas stream, the ideal gas law, and the molecular weight of SO2.

General Assumptions Used in Calculations

Variable	Value	Units
V	1,000,000	ft^3
P	14.7	psia
R	10.73	psia-ft^3/lbmol-R
T	527.7	R
md	2596.15	lbmols/MMscf
	385.1851	scf/lbmol

Ideal Gas Law used to determine the moles of gas per MSCF (P*V=n*R*T)

[3] Note that VOC emissions will actually decrease with respect to the current scenario where releases are not vented to the Flare since they will be controlled by the Flare; therefore, the potential VOC emissions associated with emergencies and malfunctions will decrease. Refer to the application text for more information.

Other Notes:

- Natural gas Higher Heating Value (Btu/scf) = 1020
- The 11A WARP project ties existing blowdown RVs to the DDU Flare header system and consists of emergency RVs only. Nitrogen will be used as the purge gas for the new header tie-ins.
- No modifications to the flare, flare knockout drum, or piping from the knockout drum to the flare required modifications to accommodate the worst case emergency relief scenarios when considering the worst case relief scenarios for the current operations
- Regulatory applicability for 40 CFR 63, Subpart CC will not change as a result of the project. Emergency RVs are not miscellaneous process vents per 40 CFR 63, Subpart CC since they are exempted from the definition in 40 CFR 63.641
- RV release gas combustion emission factors for PM/PM10/PM2.5, Lead, Mercury, and Beryllium are from AP-42 Section 1.4 (July 1998). Emission factors for VOC, NOx, and CO are from AP-42 Section 13.5 (September 1991). The emissions for SO2 are calculated
- The HHV and sulfur content was conservatively estimated based on the range of material that could be released. It was also conservatively assumed that each RV would lift one time per year, although this is an unlikely scenario.

Fugitive Emission Calculations for WARP at 11C Pipestill

Note that these counts also include work to control RVs for the 11B Coker that are part of the 11C WARP Project.

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	1	0.5789	0.0013	2.0%	0.0129	95%	100%	0.00
Light Liquid	51	0.1878	0.0037	2.0%	0.3765	95%	100%	0.08
Heavy Liquid	33	0.00051	0.00051	2.0%	0.0168	30%	100%	0.05
Pumps								
Light Liquid	2	0.9630	0.0265	2.0%	0.0905	80%	100%	0.08
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	10	0.0827	0.00013	0.3%	0.0038	30%	100%	0.01
Light Liquid	135	0.0827	0.00013	0.3%	0.0510	30%	100%	0.16
Heavy Liquid	71	0.0827	0.00013	0.3%	0.0268	30%	100%	0.08
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves - Added[3]	0	3.728	0.0985	2.0%	0.0000	98%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
Total VOC Emissions Associated with Added Components (tons/yr):								0.47

Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	-6	0.1878	0.0037	2.0%	-0.0443	95%	100%	-0.01
Heavy Liquid	-2	0.00051	0.00051	2.0%	-0.0010	30%	100%	0.00
Flanges								
Gas/Vapor	-2	0.0827	0.00013	0.3%	-0.0008	30%	100%	0.00
Light Liquid	-34	0.0827	0.00013	0.3%	-0.0128	30%	100%	-0.04
Heavy Liquid	-7	0.0827	0.00013	0.3%	-0.0026	30%	100%	-0.01
Total VOC Emissions Associated with Removed Components (tons/yr):								**-0.06**

Past Emissions from Relief Valves - Existing Controlled[3]	77	3.728	0.0985	2.0%	13.1739	90%	100%	5.77
Relief Valves - Existing Controlled[3]	77	3.728	0.0985	2.0%	13.1739	98%	100%	1.15
Emissions Reduction (Future - Past)								-4.62
Total VOC Emissions Associated with Added Components and Additional Controls (tons/yr):								**-4.21**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

[3] There are 2 new relief valves and 74 existing RV's - previously routed to the atmosphere (through the blowdown stack) that are now routed to the DDU flare. The existing RVs were previously controlled with a water spray chamber that is presumed to be capable of 90% control.

Increased Sewer Emissions from 11C WARP Project due to Added Equipment

EQUIPMENT TYPE	UNIT 11C PS - Estimated Counts
Atmospheric Drain Hub	2
Catch Basin (Pad or Paving Drain)	0
Inspection Points	0
Cleanouts	0
Above Ground Sewer Pump Out Points	
Sum of Drains	**2**
Manhole/Junction Box w/o Vent	
Manhole/Junction Box w/ CC and/or Vent	
OSBL Manholes Per Unit - Sealed	
Flare / Degassing/ KO Tanks (ie Above Ground Junction Boxes)	0
Sealed cover sumps - Gas Traps or other sumps	
Total Manholes/Junction Boxes/Sealed Sumps	**0**
Below Grade Oily Water Separator - Fixed Roof	
Below Grade Oily Water Separator - Floating Roof	
OSBL Sumps/OWS Per Unit	
Total In ground OWS/Sumps	**0**
Tanks DGO / LGO / Sour Water service	
Above Ground Oil Water Separator Tanks	
Total Above Ground Tanks	**0**

Does Not include Above ground pump out lines as are typically fugitive emissions included with fugitives

Assumptions:

All units will meet Benzene Neshaps Compliance Standards

No COV's will be utilized

AP-42 Factors - Section 5-1 Petroleum Refining 1/95 - Calculations assume 50% control on drains versus uncontrolled drain emissions in AP-42	No. of Units	Units of 1000 liters of flow	Emission Factor Value	Emission Factor Units	Total Emissions (kg/hr)
EMISSION INCREASES					
Drains Controlled	2		0.3	kg/day/unit	0.03
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)	0		0.03	kg/day/unit	0.00
Sealed Manholes	0		0.16	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS	0		0.024	**kg/1000 liters flow**	0.000
Slop oil tanks/OW surge tanks				Use Tanks Program	0.00
OWS Abv Gr (API) Controlled	0		0.024	**kg/1000 liters flow**	0.000
Subtotal for Emission Increases					0.03

EMISSION DECREASES					
Area Drains Controlled			0.3	kg/day/unit	0.00
Area Drains Uncontrolled			0.7	kg/day/unit	0.00
Process Drains Controlled			0.3	kg/day/unit	0.00
Process Drains Uncontrolled			0.7	kg/day/unit	0.00
Catch Basins Controlled			0.3	kg/day/unit	0.00
Catch Basins Uncontrolled			0.7	kg/day/unit	0.00
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)			0.03	kg/day/unit	0.00
Sealed Manholes			0.16	kg/day/unit	0.00
Junction Boxes/Manholes Uncontrolled			0.7	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS (API) Controlled			0.024	kg/1000 liters	0.00
OWS (API) Uncontrolled			0.6	kg/1000 liters	0.00
Slop oil tanks/OW surge tanks					0.00
OWS Abv Gr (API) UnControlled			0.6	kg/1000 liters	0.00
OWS Abv Gr (API) Controlled			0.024	kg/1000 liters	0.00

Subtotal for Emission Decreases	0.00

NET EMISSIONS

kg/hr	0.03
lb/d	1.52
lb/yr	556
TPY	**0.3**

Notes

Emission Source		Units	Source*
Uncontrolled Drain	0.69	Kg/day	AP-42 (e.g. 450/650)
Controlled Drain (with water trap – 50% control of AP-42)	0.0145	Kg/hr	BIDa
Sealed Manway Cover (gasketed – 77% of AP-42)	0.022	Kg/hr	BIDb
Uncontrolled Junction Box (same as an Uncontrolled Drain)	0.029	Kg/hr	AP-42 (ref. BIDa)
Controlled Junction Box (with carbon canister to comply with BWON – 5% of AP-42)	0.00145	Kg/hr	BIDa, BWON
Uncontrolled OWS	0.6	Kg/1000 liters	AP-42
Controlled OWS	0.024	Kg/1000 liters	AP-42

*Notes:
BIDa - Background Information Document to Proposed NSPS QQQ, Feb. 1985.
BIDb - Background Information Document to Proposed NSPS QQQ, Dec. 1987.
AP-42 - AP 42, Fifth Edition, Volume I Chapter 5.1 Petroleum Refining, Jan. 1995.

11B Emergency Relief Valves to the DDU Flare

Note that the work for 11B is associated with the 11C WARP project.

Process Unit	Malfunction Rates		HHV	Sulfur	Frequency	Duration	VOC				NO_X				SO_2				PM				$PM_{10}/PM_{2.5}$				CO				Pb				Hg				Be			
			BTU/scf	ppm	#/year	hours	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/day[1]	tpy	EF	Unit	lb/day[1]	tpy
C-178	0.0056525	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		9.4	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.06	0.00	0.37	lb/MMBtu	2.8	0.00	5.0E-04	lb/MMscf	3.7E-06	1.85E-09	1.84E-04	lb/MMscf	1.4E-06	6.78E-10	1.20E-05	lb/MMscf	8.9E-08	4.43E-11
C-176	0.0056525	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		9.4	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.06	0.00	0.37	lb/MMBtu	2.8	0.00	5.0E-04	lb/MMscf	3.7E-06	1.85E-09	1.84E-04	lb/MMscf	1.4E-06	6.78E-10	1.20E-05	lb/MMscf	8.9E-08	4.43E-11
C-34B	0.0157137	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	1.4	0.00	see below[2]		26.1	0.01	1.9	lb/MMscf	0.04	0.00	7.6	lb/MMscf	0.16	0.00	0.37	lb/MMBtu	7.8	0.00	5.0E-04	lb/MMscf	1.0E-05	5.14E-09	1.84E-04	lb/MMscf	3.8E-06	1.89E-09	1.20E-05	lb/MMscf	2.5E-07	1.23E-10
C-220	0.0381619	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	3.5	0.00	see below[2]		63.4	0.03	1.9	lb/MMscf	0.09	0.00	7.6	lb/MMscf	0.38	0.00	0.37	lb/MMBtu	18.8	0.01	5.0E-04	lb/MMscf	2.5E-05	1.25E-08	1.84E-04	lb/MMscf	9.2E-06	4.58E-09	1.20E-05	lb/MMscf	6.0E-07	2.99E-10
C-199	0.0022759	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		3.8	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.02	0.00	0.37	lb/MMBtu	1.1	0.00	5.0E-04	lb/MMscf	1.5E-06	7.44E-10	1.84E-04	lb/MMscf	5.5E-07	2.73E-10	1.20E-05	lb/MMscf	3.6E-08	1.79E-11
C-191	0.0008182	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		1.4	0.00	1.9	lb/MMscf	0.00	0.00	7.6	lb/MMscf	0.01	0.00	0.37	lb/MMBtu	0.4	0.00	5.0E-04	lb/MMscf	5.3E-07	2.67E-10	1.84E-04	lb/MMscf	2.0E-07	9.82E-11	1.20E-05	lb/MMscf	1.3E-08	6.42E-12
C-194	0.0055694	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		9.3	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.06	0.00	0.37	lb/MMBtu	2.7	0.00	5.0E-04	lb/MMscf	3.6E-06	1.82E-09	1.84E-04	lb/MMscf	1.3E-06	6.68E-10	1.20E-05	lb/MMscf	8.7E-08	4.37E-11
C-192	0.0055694	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		9.3	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.06	0.00	0.37	lb/MMBtu	2.7	0.00	5.0E-04	lb/MMscf	3.6E-06	1.82E-09	1.84E-04	lb/MMscf	1.3E-06	6.68E-10	1.20E-05	lb/MMscf	8.7E-08	4.37E-11
C-174	0.0033694	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		5.6	0.00	1.9	lb/MMscf	0.01	0.00	7.6	lb/MMscf	0.03	0.00	0.37	lb/MMBtu	1.7	0.00	5.0E-04	lb/MMscf	2.2E-06	1.10E-09	1.84E-04	lb/MMscf	8.1E-07	4.04E-10	1.20E-05	lb/MMscf	5.3E-08	2.64E-11
C-206	0.0003182	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.0	0.00	see below[2]		0.5	0.00	1.9	lb/MMscf	0.00	0.00	7.6	lb/MMscf	0.00	0.00	0.37	lb/MMBtu	0.2	0.00	5.0E-04	lb/MMscf	2.1E-07	1.04E-10	1.84E-04	lb/MMscf	7.6E-08	3.82E-11	1.20E-05	lb/MMscf	5.0E-09	2.50E-12
C-204	0.0018602	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		3.1	0.00	1.9	lb/MMscf	0.00	0.00	7.6	lb/MMscf	0.02	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	6.08E-10	1.84E-04	lb/MMscf	4.5E-07	2.23E-10	1.20E-05	lb/MMscf	2.9E-08	1.46E-11
C-122	0.0340966	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	3.1	0.00	see below[2]		56.7	0.03	1.9	lb/MMscf	0.08	0.00	7.6	lb/MMscf	0.34	0.00	0.37	lb/MMBtu	16.8	0.01	5.0E-04	lb/MMscf	2.2E-05	1.11E-08	1.84E-04	lb/MMscf	8.2E-06	4.09E-09	1.20E-05	lb/MMscf	5.3E-07	2.67E-10
C-160	0.0143992	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	1.3	0.00	see below[2]		23.9	0.01	1.9	lb/MMscf	0.04	0.00	7.6	lb/MMscf	0.14	0.00	0.37	lb/MMBtu	7.1	0.00	5.0E-04	lb/MMscf	9.4E-06	4.71E-09	1.84E-04	lb/MMscf	3.5E-06	1.73E-09	1.20E-05	lb/MMscf	2.3E-07	1.13E-10
C-205	0.0346873	MMscfh	4,000	30,000	1.0	0.33					0.068	lb/MMBtu	3.1	0.00	see below[2]		57.6	0.03	1.9	lb/MMscf	0.09	0.00	7.6	lb/MMscf	0.34	0.00	0.37	lb/MMBtu	17.1	0.01	5.0E-04	lb/MMscf	2.3E-05	1.13E-08	1.84E-04	lb/MMscf	8.3E-06	4.16E-09	1.20E-05	lb/MMscf	5.4E-07	2.72E-10

	VOC[3]		NO_X		SO_2		PM		$PM_{10}/PM_{2.5}$		CO		Pb		Hg		Be	
Total Projected Actual Emissions				7.6E-03		0.14		2.1E-04		8.4E-04		0.04		5.5E-08		2.0E-08		1.3E-09
Major New Source Review Thresholds		40		40		40		25		15		100		0.6		0.1		0.1
Major New Source Review Triggered?		No		No		No		No		No		No		No		No		No

[1] Event emission rate represents one worst case emergency/malfunction scenario event. Annual emission rate represents the estimated annual average total duration of worst case emergency/malfunction events.

[2] SO_2 Emissions Calculation:

SO2 MW (lb/lb-mole)=		64

SO2 emissions are calculated based on the concentration of sulfur in the gas stream, the ideal gas law, and the molecular weight of SO2.

General Assumptions Used in Calculations

Variable	Value	Units
V	1,000,000	ft^3
P	14.7	psia
R	10.73	psia-ft^3/lbmol-R
T	527.7	R
md	2596.15	lbmols/MMscf
	385.1851	scf/lbmol

Ideal Gas Law used to determine the moles of gas per MSCF (P*V=n*R*T)

[3] Note that VOC emissions will actually decrease with respect to the current scenario where releases are not vented to the Flare since they will be controlled by the Flare; therefore, the potential VOC emissions associated with emergencies and malfunctions will decrease. Refer to the application text for more information.

Other Notes:

- Natural gas Higher Heating Value (Btu/scf) = 1020
- The 11B WARP project ties existing blowdown RVs to the DDU Flare header system and consists of emergency RVs only. Nitrogen will be used as the purge gas for the new header tie-ins.
- No modifications to the flare, flare knockout drum, or piping from the knockout drum to the flare required modifications to accommodate the worst case emergency relief scenarios when considering the worst case relief scenarios for the current operations
- Regulatory applicability for 40 CFR 63, Subpart CC will not change as a result of the project. Emergency RVs are not miscellaneous process vents per 40 CFR 63, Subpart CC since they are exempted from the definition in 40 CFR 63.641
- RV release gas combustion emission factors for PM/PM10/PM2.5, Lead, Mercury, and Beryllium are from AP-42 Section 1.4 (July 1998). Emission factors for VOC, NOx, and CO are from AP-42 Section 13.5 (September 1991). The emissions for SO2 are calculated
- The HHV and sulfur content was conservatively estimated based on the range of material that could be released. It was also conservatively assumed that each RV would lift one time per year, although this is an unlikely scenario.

11C PS Emergency Relief Valves to the DDU Flare

Process Unit	Malfunction Rates		HHV	Sulfur	Frequency	Duration	VOC				NO_x				SO_2				PM				$PM_{10}/PM_{2.5}$				CO				Pb				Hg				Be			
			BTU/scf	ppm	#/year	hours	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/day[1]	tpy	EF	Unit	lb/day[1]	tpy
Z-168	0.0054585	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	5.80E-10	1.84E-04	lb/MMscf	4.3E-07	2.13E-10	1.20E-05	lb/MMscf	2.8E-08	1.39E-11
Z-203	0.0026753	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.4	0.00	5.0E-04	lb/MMscf	5.7E-07	2.84E-10	1.84E-04	lb/MMscf	2.1E-07	1.04E-10	1.20E-05	lb/MMscf	1.4E-08	6.82E-12
Z-242	0.0061985	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.0	0.00	5.0E-04	lb/MMscf	1.3E-06	6.58E-10	1.84E-04	lb/MMscf	4.8E-07	2.42E-10	1.20E-05	lb/MMscf	3.2E-08	1.58E-11
Z-154	0.0045804	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.7	0.00	5.0E-04	lb/MMscf	9.7E-07	4.86E-10	1.84E-04	lb/MMscf	3.6E-07	1.79E-10	1.20E-05	lb/MMscf	2.3E-08	1.17E-11
Z-145	0.0102079	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		0.6	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.6	0.00	5.0E-04	lb/MMscf	2.2E-06	1.08E-09	1.84E-04	lb/MMscf	8.0E-07	3.98E-10	1.20E-05	lb/MMscf	5.2E-08	2.60E-11
Z-205	0.0029595	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.2	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.5	0.00	5.0E-04	lb/MMscf	6.3E-07	3.14E-10	1.84E-04	lb/MMscf	2.3E-07	1.15E-10	1.20E-05	lb/MMscf	1.5E-08	7.54E-12
Z-237	0.0029595	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.2	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.5	0.00	5.0E-04	lb/MMscf	6.3E-07	3.14E-10	1.84E-04	lb/MMscf	2.3E-07	1.15E-10	1.20E-05	lb/MMscf	1.5E-08	7.54E-12
Z-140	0.2226303	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	6.6	0.00	see below[2]		12.3	0.01	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	0.7	0.00	0.37	lb/MMBtu	35.7	0.02	5.0E-04	lb/MMscf	4.7E-05	2.36E-08	1.84E-04	lb/MMscf	1.7E-05	8.68E-09	1.20E-05	lb/MMscf	1.1E-06	5.67E-10
Z-218	0.302738	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	8.9	0.00	see below[2]		16.8	0.01	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	1.0	0.00	0.37	lb/MMBtu	48.5	0.02	5.0E-04	lb/MMscf	6.4E-05	3.22E-08	1.84E-04	lb/MMscf	2.4E-05	1.18E-08	1.20E-05	lb/MMscf	1.5E-06	7.72E-10
Z-217	0.0102227	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		0.6	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.6	0.00	5.0E-04	lb/MMscf	2.2E-06	1.09E-09	1.84E-04	lb/MMscf	8.0E-07	3.99E-10	1.20E-05	lb/MMscf	5.2E-08	2.61E-11
Z-216	0.0069113	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.4	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.1	0.00	5.0E-04	lb/MMscf	1.5E-06	7.34E-10	1.84E-04	lb/MMscf	5.4E-07	2.70E-10	1.20E-05	lb/MMscf	3.5E-08	1.76E-11
Z-221	0.0094034	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		0.5	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.5	0.00	5.0E-04	lb/MMscf	2.0E-06	9.99E-10	1.84E-04	lb/MMscf	7.3E-07	3.67E-10	1.20E-05	lb/MMscf	4.8E-08	2.40E-11
Z-207	0.0054217	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	5.76E-10	1.84E-04	lb/MMscf	4.2E-07	2.11E-10	1.20E-05	lb/MMscf	2.8E-08	1.38E-11
Z-202	0.0045351	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.7	0.00	5.0E-04	lb/MMscf	9.6E-07	4.82E-10	1.84E-04	lb/MMscf	3.5E-07	1.77E-10	1.20E-05	lb/MMscf	2.3E-08	1.16E-11
Z-225	0.007647	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.4	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.2	0.00	5.0E-04	lb/MMscf	1.6E-06	8.12E-10	1.84E-04	lb/MMscf	6.0E-07	2.98E-10	1.20E-05	lb/MMscf	3.9E-08	1.95E-11
Z-204	0.0057253	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	6.08E-10	1.84E-04	lb/MMscf	4.5E-07	2.23E-10	1.20E-05	lb/MMscf	2.9E-08	1.46E-11
Z-228	0.202389	MMscfh	1,300	400,000	1.0	0.33					0.068	lb/MMBtu	6.0	0.00	see below[2]		4483.7	2.24	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	0.7	0.00	0.37	lb/MMBtu	32.4	0.02	5.0E-04	lb/MMscf	4.3E-05	2.15E-08	1.84E-04	lb/MMscf	1.6E-05	7.89E-09	1.20E-05	lb/MMscf	1.0E-06	5.16E-10
Z-139	0.0091026	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		0.5	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.5	0.00	5.0E-04	lb/MMscf	1.9E-06	9.67E-10	1.84E-04	lb/MMscf	7.1E-07	3.55E-10	1.20E-05	lb/MMscf	4.6E-08	2.32E-11
Z-241	0.0029595	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.2	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.5	0.00	5.0E-04	lb/MMscf	6.3E-07	3.14E-10	1.84E-04	lb/MMscf	2.3E-07	1.15E-10	1.20E-05	lb/MMscf	1.5E-08	7.54E-12
Z-101	0.2560707	MMscfh	1,300	30,000	1.0	0.33					0.068	lb/MMBtu	7.5	0.00	see below[2]		425.5	0.21	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	0.8	0.00	0.37	lb/MMBtu	41.1	0.02	5.0E-04	lb/MMscf	5.4E-05	2.72E-08	1.84E-04	lb/MMscf	2.0E-05	9.99E-09	1.20E-05	lb/MMscf	1.3E-06	6.53E-10
Z-107	0.8227902	MMscfh	4,496	1,000	1.0	0.33					0.068	lb/MMBtu	83.9	0.04	see below[2]		45.6	0.02	1.9	lb/MMscf	2.3	0.00	7.6	lb/MMscf	9.2	0.00	0.37	lb/MMBtu	456.3	0.23	5.0E-04	lb/MMscf	6.0E-04	3.02E-07	1.84E-04	lb/MMscf	2.2E-04	1.11E-07	1.20E-05	lb/MMscf	1.5E-05	7.25E-09
Z-222	0.002347	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.4	0.00	5.0E-04	lb/MMscf	5.0E-07	2.49E-10	1.84E-04	lb/MMscf	1.8E-07	9.15E-11	1.20E-05	lb/MMscf	1.2E-08	5.98E-12
Z-220	0.0056081	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	5.96E-10	1.84E-04	lb/MMscf	4.4E-07	2.19E-10	1.20E-05	lb/MMscf	2.9E-08	1.43E-11
Z-114	0.0047881	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.8	0.00	5.0E-04	lb/MMscf	1.0E-06	5.09E-10	1.84E-04	lb/MMscf	3.7E-07	1.87E-10	1.20E-05	lb/MMscf	2.4E-08	1.22E-11
Z-156	0.0036926	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.2	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.6	0.00	5.0E-04	lb/MMscf	7.8E-07	3.92E-10	1.84E-04	lb/MMscf	2.9E-07	1.44E-10	1.20E-05	lb/MMscf	1.9E-08	9.41E-12
Z-116	0.0104647	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.3	0.00	see below[2]		0.6	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	1.7	0.00	5.0E-04	lb/MMscf	2.2E-06	1.11E-09	1.84E-04	lb/MMscf	8.2E-07	4.08E-10	1.20E-05	lb/MMscf	5.3E-08	2.67E-11
Z-134	0.0021965	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.1	0.00	see below[2]		0.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.4	0.00	5.0E-04	lb/MMscf	4.7E-07	2.33E-10	1.84E-04	lb/MMscf	1.7E-07	8.57E-11	1.20E-05	lb/MMscf	1.1E-08	5.60E-12
Z-121	0.2713905	MMscfh	5,662	1,000	1.0	0.33					0.068	lb/MMBtu	34.8	0.02	see below[2]		15.0	0.01	1.9	lb/MMscf	1.0	0.00	7.6	lb/MMscf	3.8	0.00	0.37	lb/MMBtu	189.5	0.09	5.0E-04	lb/MMscf	2.5E-04	1.26E-07	1.84E-04	lb/MMscf	9.2E-05	4.61E-08	1.20E-05	lb/MMscf	6.0E-06	3.01E-09
Z-132	0.0054392	MMscfh	1,300	1,000	1.0	0.33					0.068	lb/MMBtu	0.2	0.00	see below[2]		0.3	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	0.9	0.00	5.0E-04	lb/MMscf	1.2E-06	5.78E-10	1.84E-04	lb/MMscf	4.2E-07	2.12E-10	1.20E-05	lb/MMscf	2.8E-08	1.39E-11

	VOC[3]		NO_x		SO_2		PM		$PM_{10}/PM_{2.5}$		CO		Pb		Hg		Be	
Total Projected Actual Emissions				0.08		2.50		0.00		0.01		0.4		5.5E-07		2.0E-07		1.3E-08
Major New Source Review Thresholds		40		40		40		25		15		100		0.6		0.1		0.1
Major New Source Review Triggered?		N		No		No		No		No		No		No		No		No

[1] Event emission rate represents one worst case emergency/malfunction scenario event. Annual emission rate represents the estimated annual average total duration of worst case emergency/malfunction events.

[2] SO_2 Emissions Calculation:

SO2 MW (lb/lb-mole)=		64

SO2 emissions are calculated based on the concentration of sulfur in the gas stream, the ideal gas law, and the molecular weight of SO2.

General Assumptions Used in Calculations

Variable	Value	Units
V	1,000,000	ft^3
P	14.7	psia
R	10.73	psia-ft^3/lbmol-R
T	527.7	R
md	2596.15	lbmols/MMscf
	385.1851	scf/lbmol

Ideal Gas Law used to determine the moles of gas per MSCF (P*V=n*R*T)

[3] Note that VOC emissions will actually decrease with respect to the current scenario where releases are not vented to the Flare since they will be controlled by the Flare; therefore, the potential VOC emissions associated with emergencies and malfunction

Other Notes:

- Natural gas Higher Heating Value (Btu/scf) = 1020
- The 11C WARP project ties existing blowdown RVs to the DDU Flare header system and consists of emergency RVs only. Nitrogen will be used as the purge gas for the new header tie-ins.
- No modifications to the flare, flare knockout drum, or piping from the knockout drum to the flare required modifications to accommodate the worst case emergency relief scenarios when considering the worst case relief scenarios for the current operations
- Regulatory applicability for 40 CFR 63, Subpart CC will not change as a result of the project. Emergency RVs are not miscellaneous process vents per 40 CFR 63, Subpart CC since they are exempted from the definition in 40 CFR 63.641
- RV release gas combustion emission factors for PM/PM10/PM2.5, Lead, and Mercury are from AP-42 Section 1.4 (July 1998). Emission factors for VOC, NOx, and CO are from AP-42 Section 13.5 (September 1991). The emissions for SO2 are calculated by assumin
- The HHV and sulfur content was conservatively estimated based on the range of material that could be released. It was also conservatively assumed that each RV would lift one time per year, although this is an unlikely scenario.

Fugitive Emission Calculations for WARP at FCU500

Refer to application text for more information regarding FCU 500 WARP and these estimated component counts.

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	93	0.1878	0.0037	2.0%	0.6865	95%	100%	0.15
Heavy Liquid	4	0.00051	0.00051	2.0%	0.0020	30%	100%	0.01
Pumps								
Light Liquid	1	0.9630	0.0265	2.0%	0.0452	80%	100%	0.04
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	1	0.0827	0.00013	0.3%	0.0004	30%	100%	0.00
Light Liquid	192	0.0827	0.00013	0.3%	0.0725	30%	100%	0.22
Heavy Liquid	11	0.0827	0.00013	0.3%	0.0042	30%	100%	0.01
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	0	3.728	0.0985	2.0%	0.0000	100%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
							Total VOC Emissions (tons/yr):	**0.43**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

Relief Valves are controlled

Increased Sewer Emissions from FCU500 WARP Project due to Added Equipment

EQUIPMENT TYPE	UNIT FCU500 - Estimated Counts
Atmospheric Drain Hub	4
Catch Basin (Pad or Paving Drain)	0
Inspection Points	0
Cleanouts	0
Above Ground Sewer Pump Out Points	
Sum of Drains	**4**
Manhole/Junction Box w/o Vent	
Manhole/Junction Box w/ CC and/or Vent	
OSBL Manholes Per Unit - Sealed	
Flare / Degassing/ KO Tanks (ie Above Ground Junction Boxes)	0
Sealed cover sumps - Gas Traps or other sumps	
Total Manholes/Junction Boxes/Sealed Sumps	**0**
Below Grade Oily Water Separator - Fixed Roof	
Below Grade Oily Water Separator - Floating Roof	
OSBL Sumps/OWS Per Unit	
Total In ground OWS/Sumps	**0**
Tanks DGO / LGO / Sour Water service	
Above Ground Oil Water Separator Tanks	
Total Above Ground Tanks	**0**

Does Not include Above ground pump out lines as are typically fugitive emissions included with fugitives

Assumptions:

All units will meet Benzene Neshaps Compliance Standards

No COV's will be utilized

AP-42 Factors - Section 5-1 Petroleum Refining 1/95 - Calculations assume 50% control on drains versus uncontrolled drain emissions in AP-42		No. of Units	Units of 1000 liters of flow	Emission Factor Value	Emission Factor Units	Total Emissions (kg/hr)
EMISSION INCREASES						
Drains Controlled		4		0.3	kg/day/unit	0.06
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)		0		0.03	kg/day/unit	0.00
Sealed Manholes		0		0.16	kg/day/unit	0.00
Oil Water Separator and Auxillaries						
	OWS	0		0.024	**kg/1000 liters flow**	0.000
	Slop oil tanks/OW surge tanks				Use Tanks Program	0.00
	OWS Abv Gr (API) Controlled	0		0.024	**kg/1000 liters flow**	0.000
Subtotal for Emission Increases						0.06
EMISSION DECREASES						
Area Drains Controlled				0.3	kg/day/unit	0.00
Area Drains Uncontrolled				0.7	kg/day/unit	0.00
Process Drains Controlled				0.3	kg/day/unit	0.00
Process Drains Uncontrolled				0.7	kg/day/unit	0.00
Catch Basins Controlled				0.3	kg/day/unit	0.00
Catch Basins Uncontrolled				0.7	kg/day/unit	0.00
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)				0.03	kg/day/unit	0.00
Sealed Manholes				0.16	kg/day/unit	0.00
Junction Boxes/Manholes Uncontrolled				0.7	kg/day/unit	0.00
Oil Water Separator and Auxillaries						
	OWS (API) Controlled			0.024	kg/1000 liters	0.00
	OWS (API) Uncontrolled			0.6	kg/1000 liters	0.00
	Slop oil tanks/OW surge tanks					0.00
	OWS Abv Gr (API) UnControlled			0.024	kg/1000 liters	0.00
	OWS Abv Gr (API) Controlled			0.6	kg/1000 liters	0.00
Subtotal for Emission Decreases						0.00

NET EMISSIONS

kg/hr	0.06
lb/d	3.05
lb/yr	1112
TPY	**0.6**

Notes:

Emission Source		Units	Source*
Uncontrolled Drain	0.69	Kg/day	AP-42 (e.g. 450/650)
Controlled Drain (with water trap – 50% control of AP-42)	0.0145	Kg/hr	BIDa
Sealed Manway Cover (gasketed – 77% of AP-42)	0.022	Kg/hr	BIDb
Uncontrolled Junction Box (same as an Uncontrolled Drain)	0.029	Kg/hr	AP-42 (ref. BIDa)
Controlled Junction Box (with carbon canister to comply with BWON – 5% of AP-42)	0.00145	Kg/hr	BIDa, BWON
Uncontrolled OWS	0.6	Kg/1000 liters	AP-42
Controlled OWS	0.024	Kg/1000 liters	AP-42

*Notes:
BIDa - Background Information Document to Proposed NSPS QQQ, Feb. 1985.
BIDb - Background Information Document to Proposed NSPS QQQ, Dec. 1987.
AP-42 - AP 42, Fifth Edition, Volume I Chapter 5.1 Petroleum Refining, Jan. 1995.

Fugitive Emission Calculations for WARP at FCU 600

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	93	0.1878	0.0037	2.0%	0.6865	95%	100%	0.15
Heavy Liquid	4	0.00051	0.00051	2.0%	0.0020	30%	100%	0.01
Pumps								
Light Liquid	1	0.9630	0.0265	2.0%	0.0452	80%	100%	0.04
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	1	0.0827	0.00013	0.3%	0.0004	30%	100%	0.00
Light Liquid	192	0.0827	0.00013	0.3%	0.0725	30%	100%	0.22
Heavy Liquid	11	0.0827	0.00013	0.3%	0.0042	30%	100%	0.01
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves - Added[3]	0	3.728	0.0985	2.0%	0.0000	98%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
							Total VOC Emissions Associated with Added Components (tons/yr):	0.43

Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	-15	0.1878	0.0037	2.0%	-0.1107	95%	100%	-0.02
Heavy Liquid	-2	0.00051	0.00051	2.0%	-0.0010	30%	100%	0.00
Flanges								
Gas/Vapor	-6	0.0827	0.00013	0.3%	-0.0023	30%	100%	-0.01
Light Liquid	-22	0.0827	0.00013	0.3%	-0.0083	30%	100%	-0.03
Heavy Liquid	-7	0.0827	0.00013	0.3%	-0.0026	30%	100%	-0.01
							Total VOC Emissions Associated with Removed Components (tons/yr):	**-0.07**

Past Emissions from Relief Valves - Existing Controlled[3]	41	3.728	0.0985	2.0%	7.0147	90%	100%	3.07
Relief Valves - Existing Controlled[3]	41	3.728	0.0985	2.0%	7.0147	98%	100%	0.61
Emissions Reduction (Future - Past)								-2.46
Total VOC Emissions Associated with Added Components and Additional Controls (tons/yr):								**-2.09**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

[3] There are no new relief valves and 41 existing RV's - previously routed to the atmosphere (through the blowdown stack) that are now routed to the FCU flare. The existing RVs were previously controlled with a water spray chamber that is presumed to be capable of 90% control.

Increased Sewer Emissions from FCU600 WARP Project due to Added Equipment

EQUIPMENT TYPE	UNIT FCU600 - Estimated Counts
Atmospheric Drain Hub	4
Catch Basin (Pad or Paving Drain)	0
Inspection Points	0
Cleanouts	0
Above Ground Sewer Pump Out Points	
Sum of Drains	**4**
Manhole/Junction Box w/o Vent	
Manhole/Junction Box w/ CC and/or Vent	1
OSBL Manholes Per Unit - Sealed	
Flare / Degassing/ KO Tanks (ie Above Ground Junction Boxes)	0
Sealed cover sumps - Gas Traps or other sumps	
Total Manholes/Junction Boxes/Sealed Sumps	**1**
Below Grade Oily Water Separator - Fixed Roof	
Below Grade Oily Water Separator - Floating Roof	
OSBL Sumps/OWS Per Unit	
Total In ground OWS/Sumps	**0**
Tanks DGO / LGO / Sour Water service	
Above Ground Oil Water Separator Tanks	
Total Above Ground Tanks	**0**

Does Not include Above ground pump out lines as are typically fugitive emissions included with fugitives

Assumptions:
All units will meet Benzene Neshaps Compliance Standards
No COV's will be utilized

AP-42 Factors - Section 5-1 Petroleum Refining 1/95 - Calculations assume 50% control on drains versus uncontrolled drain emissions in AP-42	No. of Units	Units of 1000 liters of flow	Emission Factor Value	Emission Factor Units	Total Emissions (kg/hr)
EMISSION INCREASES					
Drains Controlled	4		0.3	kg/day/unit	0.06
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)	0		0.03	kg/day/unit	0.00
Sealed Manholes	0		0.16	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS	0		0.024	**kg/1000 liters flow**	0.000
Slop oil tanks/OW surge tanks				Use Tanks Program	0.00
OWS Abv Gr (API) Controlled	0		0.024	**kg/1000 liters flow**	0.000
Subtotal for Emission Increases					0.06

EMISSION DECREASES					
Area Drains Controlled			0.3	kg/day/unit	0.00
Area Drains Uncontrolled			0.7	kg/day/unit	0.00
Process Drains Controlled			0.3	kg/day/unit	0.00
Process Drains Uncontrolled			0.7	kg/day/unit	0.00
Catch Basins Controlled			0.3	kg/day/unit	0.00
Catch Basins Uncontrolled			0.7	kg/day/unit	0.00
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)			0.03	kg/day/unit	0.00
Sealed Manholes			0.16	kg/day/unit	0.00
Junction Boxes/Manholes Uncontrolled			0.7	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS (API) Controlled			0.024	kg/1000 liters	0.00
OWS (API) Uncontrolled			0.6	kg/1000 liters	0.00
Slop oil tanks/OW surge tanks					0.00
OWS Abv Gr (API) UnControlled			0.024	kg/1000 liters	0.00
OWS Abv Gr (API) Controlled			0.6	kg/1000 liters	0.00

Subtotal for Emission Decreases	0.00

NET EMISSIONS

kg/hr	0.06
lb/d	3.05
lb/yr	1112
TPY	**0.6**

Notes:

Emission Source		Units	Source*
Uncontrolled Drain	0.69	Kg/day	AP-42 (e.g. 450/650)
Controlled Drain (with water trap – 50% control of AP-42)	0.0145	Kg/hr	BIDa
Sealed Manway Cover (gasketed – 77% of AP-42)	0.022	Kg/hr	BIDb
Uncontrolled Junction Box (same as an Uncontrolled Drain)	0.029	Kg/hr	AP-42 (ref. BIDa)
Controlled Junction Box (with carbon canister to comply with BWON – 5% of AP-42)	0.00145	Kg/hr	BIDa, BWON
Uncontrolled OWS	0.6	Kg/1000 liters	AP-42
Controlled OWS	0.024	Kg/1000 liters	AP-42

*Notes:
BIDa - Background Information Document to Proposed NSPS QQQ, Feb. 1985.
BIDb - Background Information Document to Proposed NSPS QQQ, Dec. 1987.
AP-42 - AP 42, Fifth Edition, Volume I Chapter 5.1 Petroleum Refining, Jan. 1995.

FCU 600 Emergency Relief Valves to the FCU Flare

RV's	Malfunction Rates		HHV	Sulfur	Frequency	Duration	VOC				NO_X				SO_2				PM				$PM_{10}/PM_{2.5}$				CO				Pb				Hg				Be			
			BTU/scf	ppm	#/year	hours	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/day[1]	tpy	EF	Unit	lb/day[1]	tpy
R-0041	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-0045	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-0049	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-0047	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-0048	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-0051	1.33E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.9	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.4	0.00	5.0E-04	lb/MMscf	3.2E-06	1.59E-09	1.84E-04	lb/MMscf	1.2E-06	5.85E-10	1.20E-05	lb/MMscf	7.6E-08	3.82E-11
R-2099	2.52E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.8	0.00	see below[2]		1.7	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	4.5	0.00	5.0E-04	lb/MMscf	6.0E-06	3.01E-09	1.84E-04	lb/MMscf	2.2E-06	1.10E-09	1.20E-05	lb/MMscf	1.4E-07	7.22E-11
R-2100	2.52E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.8	0.00	see below[2]		1.7	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	4.5	0.00	5.0E-04	lb/MMscf	6.0E-06	3.01E-09	1.84E-04	lb/MMscf	2.2E-06	1.10E-09	1.20E-05	lb/MMscf	1.4E-07	7.22E-11
R-2010	2.74E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.9	0.00	see below[2]		1.8	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	4.9	0.00	5.0E-04	lb/MMscf	6.5E-06	3.27E-09	1.84E-04	lb/MMscf	2.4E-06	1.20E-09	1.20E-05	lb/MMscf	1.6E-07	7.85E-11
R-2011	2.74E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.9	0.00	see below[2]		1.8	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	4.9	0.00	5.0E-04	lb/MMscf	6.5E-06	3.27E-09	1.84E-04	lb/MMscf	2.4E-06	1.20E-09	1.20E-05	lb/MMscf	1.6E-07	7.85E-11
R-2107	2.26E-03	MMscfh	12,338	11,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.4	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.4	0.00	5.0E-04	lb/MMscf	4.5E-06	2.27E-09	1.84E-04	lb/MMscf	1.7E-06	8.35E-10	1.20E-05	lb/MMscf	1.1E-07	5.46E-11
R-2108	2.26E-03	MMscfh	12,338	11,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.4	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.4	0.00	5.0E-04	lb/MMscf	4.5E-06	2.27E-09	1.84E-04	lb/MMscf	1.7E-06	8.35E-10	1.20E-05	lb/MMscf	1.1E-07	5.46E-11
R-2069	2.72E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.3	0.00	5.0E-04	lb/MMscf	4.4E-06	2.19E-09	1.84E-04	lb/MMscf	1.6E-06	8.05E-10	1.20E-05	lb/MMscf	1.1E-07	5.26E-11
R-2054	2.72E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.3	0.00	5.0E-04	lb/MMscf	4.4E-06	2.19E-09	1.84E-04	lb/MMscf	1.6E-06	8.05E-10	1.20E-05	lb/MMscf	1.1E-07	5.26E-11
R-2055	4.09E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.9	0.00	see below[2]		1.6	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	5.0	0.00	5.0E-04	lb/MMscf	6.6E-06	3.30E-09	1.84E-04	lb/MMscf	2.4E-06	1.21E-09	1.20E-05	lb/MMscf	1.6E-07	7.91E-11
R-2004	2.76E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.1	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.4	0.00	5.0E-04	lb/MMscf	4.4E-06	2.22E-09	1.84E-04	lb/MMscf	1.6E-06	8.17E-10	1.20E-05	lb/MMscf	1.1E-07	5.34E-11
R-2007	1.47E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		1.0	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	2.7	0.00	5.0E-04	lb/MMscf	3.5E-06	1.76E-09	1.84E-04	lb/MMscf	1.3E-06	6.46E-10	1.20E-05	lb/MMscf	8.4E-08	4.22E-11
R-2020	2.65E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.6	0.00	see below[2]		1.0	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	3.2	0.00	5.0E-04	lb/MMscf	4.3E-06	2.14E-09	1.84E-04	lb/MMscf	1.6E-06	7.86E-10	1.20E-05	lb/MMscf	1.0E-07	5.13E-11
R-2053	1.18E-03	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	0.4	0.00	see below[2]		0.8	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.0	0.00	0.37	lb/MMBtu	2.1	0.00	5.0E-04	lb/MMscf	2.8E-06	1.40E-09	1.84E-04	lb/MMscf	1.0E-06	5.16E-10	1.20E-05	lb/MMscf	6.7E-08	3.37E-11
R-2070	3.48E-02	MMscfh	12,338	11,000	1	0.33					0.068	lb/MMBtu	9.7	0.00	see below[2]		21.2	0.01	1.9	lb/MMscf	0.3	0.00	7.6	lb/MMscf	1.1	0.00	0.37	lb/MMBtu	52.9	0.03	5.0E-04	lb/MMscf	7.0E-05	3.50E-08	1.84E-04	lb/MMscf	2.6E-05	1.29E-08	1.20E-05	lb/MMscf	1.7E-06	8.41E-10
R-2101	3.57E-02	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	8.0	0.00	see below[2]		13.8	0.01	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	0.9	0.00	0.37	lb/MMBtu	43.5	0.02	5.0E-04	lb/MMscf	5.8E-05	2.88E-08	1.84E-04	lb/MMscf	2.1E-05	1.06E-08	1.20E-05	lb/MMscf	1.4E-06	6.92E-10
R-1023	3.98E-02	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	8.9	0.00	see below[2]		15.4	0.01	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	1.0	0.00	0.37	lb/MMBtu	48.5	0.02	5.0E-04	lb/MMscf	6.4E-05	3.22E-08	1.84E-04	lb/MMscf	2.4E-05	1.18E-08	1.20E-05	lb/MMscf	1.5E-06	7.72E-10
R-0920	1.33E-02	MMscfh	14,626	12,000	1	0.33					0.068	lb/MMBtu	4.4	0.00	see below[2]		8.9	0.00	1.9	lb/MMscf	0.1	0.00	7.6	lb/MMscf	0.5	0.00	0.37	lb/MMBtu	24.1	0.01	5.0E-04	lb/MMscf	3.2E-05	1.59E-08	1.84E-04	lb/MMscf	1.2E-05	5.85E-09	1.20E-05	lb/MMscf	7.7E-07	3.83E-10
R-2092	2.66E-02	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	6.0	0.00	see below[2]		10.3	0.01	1.9	lb/MMscf	0.2	0.00	7.6	lb/MMscf	0.7	0.00	0.37	lb/MMBtu	32.5	0.02	5.0E-04	lb/MMscf	4.3E-05	2.15E-08	1.84E-04	lb/MMscf	1.6E-05	7.90E-09	1.20E-05	lb/MMscf	1.0E-06	5.16E-10
R-0926	2.05E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		0.8	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	2.5	0.00	5.0E-04	lb/MMscf	3.3E-06	1.66E-09	1.84E-04	lb/MMscf	1.2E-06	6.08E-10	1.20E-05	lb/MMscf	8.0E-08	3.98E-11
R-0928	2.05E-03	MMscfh	9,880	7,000	1	0.33					0.068	lb/MMBtu	0.5	0.00	see below[2]		0.8	0.00	1.9	lb/MMscf	0.0	0.00	7.6	lb/MMscf	0.1	0.00	0.37	lb/MMBtu	2.5	0.00	5.0E-04	lb/MMscf	3.3E-06	1.66E-09	1.84E-04	lb/MMscf	1.2E-06	6.08E-10	1.20E-05	lb/MMscf	8.0E-08	3.98E-11

	VOC[3]		NO_X		SO_2		PM		$PM_{10}/PM_{2.5}$		CO		Pb		Hg		Be	
Total Projected Actual Emissions				0.02		0.05		6.8E-04		2.7E-03		0.1		1.8E-07		6.6E-08		4.3E-09
Major New Source Review Thresholds		40		40		40		25		15		100		0.6		0.1		0.1
Major New Source Review Triggered?		No		No		No		No		No		No		No		No		No

[1] Event emission rate represents one worst case emergency/malfunction scenario event. Annual emission rate represents the estimated annual average total duration of worst case emergency/malfunction events.

[2] SO_2 Emissions Calculation:

SO2 MW (lb/lb-mole)=		64

SO2 emissions are calculated based on the concentration of sulfur in the gas stream, the ideal gas law, and the molecular weight of SO2.

General Assumptions Used in Calculations

Variable	Value	Units
V	1,000,000	ft^3
P	14.7	psia
R	10.73	psia-ft^3/lbmol-R
T	527.7	R
md	2596.15	lbmols/MMscf
	385.1851	scf/lbmol

Ideal Gas Law used to determine the moles of gas per MSCF (P*V=n*R*T)

[3] Note that VOC emissions will actually decrease with respect to the current scenario where releases are not vented to the Flare since they will be controlled by the Flare; therefore, the potential VOC emissions associated with emergencies and malfunctions will decrease. Refer to the application text for more information.

Other Notes:

- Natural gas Higher Heating Value (Btu/sct) = 1020
- The FCU 600 WARP project ties existing blowdown RVs to the FCU Flare header system and consists of emergency RVs only. Nitrogen will be used as the purge gas for the new header tie-ins.
- No modifications to the flare, flare knockout drum, or piping from the knockout drum to the flare required modifications to accommodate the worst case emergency relief scenarios when considering the worst case relief scenarios for the current operations
- Regulatory applicability for 40 CFR 63, Subpart CC will not change as a result of the project. Emergency RVs are not miscellaneous process vents per 40 CFR 63, Subpart CC since they are exempted from the definition in 40 CFR 63.641
- RV release gas combustion emission factors for PM/PM10/PM2.5, Lead, Beryllium, and Mercury are from AP-42 Section 1.4 (July 1998). Emission factors for VOC, NOx, and CO are from AP-42 Section 13.5 (September 1991). The emissions for SO2 are calculated

Fugitive Emission Calculations for FCU600 TAR

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	10	0.5789	0.0013	2.0%	0.1285	95%	100%	0.03
Light Liquid	26	0.1878	0.0037	2.0%	0.1919	95%	100%	0.04
Heavy Liquid	24	0.00051	0.00051	2.0%	0.0122	30%	100%	0.04
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	26	0.0827	0.00013	0.3%	0.0098	30%	100%	0.03
Light Liquid	78	0.0827	0.00013	0.3%	0.0295	30%	100%	0.09
Heavy Liquid	63	0.0827	0.00013	0.3%	0.0238	30%	100%	0.07
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	0	3.728	0.0985	2.0%	0.0000	100%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
							Total VOC Emissions (tons/yr):	**0.30**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

Relief Valves are controlled

Fugitive Emission Calculations for WARP at VRU 100

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	1	0.5789	0.0013	2.0%	0.0129	95%	100%	0.00
Light Liquid	15	0.1878	0.0037	2.0%	0.1107	95%	100%	0.02
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	11	0.0827	0.00013	0.3%	0.0042	30%	100%	0.01
Light Liquid	30	0.0827	0.00013	0.3%	0.0113	30%	100%	0.03
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves - Added[3]	0	3.728	0.0985	2.0%	0.0000	98%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
Total VOC Emissions Associated with Added Components (tons/yr):								0.07

Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	-5	0.1878	0.0037	2.0%	-0.0369	95%	100%	-0.01
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Light Liquid	-16	0.0827	0.00013	0.3%	-0.0060	30%	100%	-0.02
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Total VOC Emissions Associated with Removed Components (tons/yr):								**-0.03**

Past Emissions from Relief Valves - Existing Controlled[3]	2	3.728	0.0985	2.0%	0.3422	90%	100%	0.15
Relief Valves - Existing Controlled[3]	2	3.728	0.0985	2.0%	0.3422	98%	100%	0.03
Emissions Reduction (Future - Past)								-0.12
Total VOC Emissions Associated with Added Components and Additional Controls (tons/yr):								**-0.07**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

[3] There are no new relief valves and 2existing RV's - previously routed to the atmosphere (through the blowdown stack) that are now routed to the VRU flare. The existing RVs were previously controlled with a water spray chamber that is presumed to be capable of 90% control.

Fugitive Emission Calculations for WARP at VRU 200

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	1	0.5789	0.0013	2.0%	0.0129	95%	100%	0.00
Light Liquid	3	0.1878	0.0037	2.0%	0.0221	95%	100%	0.00
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	7	0.0827	0.00013	0.3%	0.0026	30%	100%	0.01
Light Liquid	7	0.0827	0.00013	0.3%	0.0026	30%	100%	0.01
Heavy Liquid	1	0.0827	0.00013	0.3%	0.0004	30%	100%	0.00
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves - Added[3]	0	3.728	0.0985	2.0%	0.0000	98%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
Total VOC Emissions Associated with Added Components (tons/yr):								0.03

Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	-3	0.1878	0.0037	2.0%	-0.0221	95%	100%	0.00
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Light Liquid	-5	0.0827	0.00013	0.3%	-0.0019	30%	100%	-0.01
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Total VOC Emissions Associated with Removed Components (tons/yr):								**-0.01**

Past Emissions from Relief Valves - Existing Controlled[3]	4	3.728	0.0985	2.0%	0.6844	90%	100%	0.30
Relief Valves - Existing Controlled[3]	4	3.728	0.0985	2.0%	0.6844	98%	100%	0.06
Emissions Reduction (Future - Past)								-0.24
Total VOC Emissions Associated with Added Components and Additional Controls (tons/yr):								**-0.23**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

[3] There are no new relief valves and 4 existing RV's - previously routed to the atmosphere (through the blowdown stack) that are now routed to the VRU flare. The existing RVs were previously controlled with a water spray chamber that is presumed to be capable of 90% control.

Increased Sewer Emissions from VRU 100/200 WARP Project due to Added Equipment

EQUIPMENT TYPE	UNIT VRU 100/200 - Estimated Counts	
Atmospheric Drain Hub	1	
Catch Basin (Pad or Paving Drain)	0	
Inspection Points	0	
Cleanouts	0	
Above Ground Sewer Pump Out Points		
Sum of Drains	**1**	*Does Not include Above ground pump out lines as are typically fugitive emissions included with fugitives*
Manhole/Junction Box w/o Vent		
Manhole/Junction Box w/ CC and/or Vent		
OSBL Manholes Per Unit - Sealed		
Flare / Degassing/ KO Tanks (ie Above Ground Junction Boxes)	0	
Sealed cover sumps - Gas Traps or other sumps		
Total Manholes/Junction Boxes/Sealed Sumps	**0**	
Below Grade Oily Water Separator - Fixed Roof		
Below Grade Oily Water Separator - Floating Roof		
OSBL Sumps/OWS Per Unit		
Total In ground OWS/Sumps	**0**	
Tanks DGO / LGO / Sour Water service		
Above Ground Oil Water Separator Tanks		
Total Above Ground Tanks	**0**	

Assumptions:
All units will meet Benzene Neshaps Compliance Standards
No COV's will be utilized

AP-42 Factors - Section 5-1 Petroleum Refining 1/95 - Calculations assume 50% control on drains versus uncontrolled drain emissions in AP-42	No. of Units	Units of 1000 liters of flow	Emission Factor Value	Emission Factor Units	Total Emissions (kg/hr)
EMISSION INCREASES					
Drains Controlled	1		0.3	kg/day/unit	0.01
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)	0		0.03	kg/day/unit	0.00
Sealed Manholes	0		0.16	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS	0		0.024	**kg/1000 liters flow**	0.000
Slop oil tanks/OW surge tanks				Use Tanks Program	0.00
OWS Abv Gr (API) Controlled	0		0.024	**kg/1000 liters flow**	0.000
Subtotal for Emission Increases					0.01

EMISSION DECREASES					
Area Drains Controlled			0.3	kg/day/unit	0.00
Area Drains Uncontrolled			0.7	kg/day/unit	0.00
Process Drains Controlled			0.3	kg/day/unit	0.00
Process Drains Uncontrolled			0.7	kg/day/unit	0.00
Catch Basins Controlled			0.3	kg/day/unit	0.00
Catch Basins Uncontrolled			0.7	kg/day/unit	0.00
Junction Boxes/Manholes Controlled (Carbon Canister to comply with BWON)			0.03	kg/day/unit	0.00
Sealed Manholes			0.16	kg/day/unit	0.00
Junction Boxes/Manholes Uncontrolled			0.7	kg/day/unit	0.00
Oil Water Separator and Auxillaries					
OWS (API) Controlled			0.024	kg/1000 liters	0.00
OWS (API) Uncontrolled			0.6	kg/1000 liters	0.00
Slop oil tanks/OW surge tanks					0.00
OWS Abv Gr (API) UnControlled			0.024	kg/1000 liters	0.00
OWS Abv Gr (API) Controlled			0.6	kg/1000 liters	0.00

Subtotal for Emission Decreases	0.00

NET EMISSIONS

kg/hr	0.01
lb/d	0.76
lb/yr	278
TPY	**0.1**

Notes:

Emission Source		Units	Source*
Uncontrolled Drain	0.69230769	Kg/day	AP-42 (e.g. 450/650)
Controlled Drain (with water trap – 50% control of AP-42)	0.0145	Kg/hr	BIDa
Sealed Manway Cover (gasketed – 77% of AP-42)	0.022	Kg/hr	BIDb
Uncontrolled Junction Box (same as an Uncontrolled Drain)	0.029	Kg/hr	AP-42 (ref. BIDa)
Controlled Junction Box (with carbon canister to comply with BWON – 5% of AP-42)	0.00145	Kg/hr	BIDa, BWON
Uncontrolled OWS	0.6	Kg/1000 liters	AP-42
Controlled OWS	0.024	Kg/1000 liters	AP-42

*Notes:
BIDa - Background Information Document to Proposed NSPS QQQ, Feb. 1985.
BIDb - Background Information Document to Proposed NSPS QQQ, Dec. 1987.
AP-42 - AP 42, Fifth Edition, Volume I Chapter 5.1 Petroleum Refining, Jan. 1995.

VRU 100 and VRU 200 Emergency Relief Valves to the VRU Flare

Process Unit	Malfunction Rates		HHV	Sulfur	Frequency	Duration	VOC				NO_X				SO_2				PM				$PM_{10}/PM_{2.5}$				CO				Pb				Hg				Be			
			BTU/scf	ppm	#/year	hours	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/event[1]	tpy	EF	Unit	lb/day[1]	tpy	EF	Unit	lb/day[1]	tpy
SV-963	0.00326	MMscfh	12,338	11,000	1.0	0.33					0.068	lb/MMBtu	0.9	0.00	see below[2]		2.0	0.00	1.9	lb/MMscf	0.02	0.00	7.6	lb/MMscf	0.10	0.00	0.37	lb/MMBtu	5.0	0.00	5.0E-04	lb/MMscf	6.6E-06	3.29E-09	1.84E-04	lb/MMscf	2.4E-06	1.21E-09	1.20E-05	lb/MMscf	1.6E-07	7.89E-11
SV-972	0.00660	MMscfh	9,880	7,000	1.0	0.33					0.068	lb/MMBtu	1.5	0.00	see below[2]		2.6	0.00	1.9	lb/MMscf	0.04	0.00	7.6	lb/MMscf	0.16	0.00	0.37	lb/MMBtu	8.0	0.00	5.0E-04	lb/MMscf	1.1E-05	5.33E-09	1.84E-04	lb/MMscf	3.9E-06	1.96E-09	1.20E-05	lb/MMscf	2.6E-07	1.28E-10
T-519	0.01424	MMscfh	9,880	7,000	1.0	0.33					0.068	lb/MMBtu	3.2	0.00	see below[2]		5.5	0.00	1.9	lb/MMscf	0.09	0.00	7.6	lb/MMscf	0.35	0.00	0.37	lb/MMBtu	17.3	0.01	5.0E-04	lb/MMscf	2.3E-05	1.15E-08	1.84E-04	lb/MMscf	8.4E-06	4.22E-09	1.20E-05	lb/MMscf	5.5E-07	2.76E-10
T-528	0.00467	MMscfh	9,880	7,000	1.0	0.33					0.068	lb/MMBtu	1.0	0.00	see below[2]		1.8	0.00	1.9	lb/MMscf	0.03	0.00	7.6	lb/MMscf	0.11	0.00	0.37	lb/MMBtu	5.7	0.00	5.0E-04	lb/MMscf	7.5E-06	3.77E-09	1.84E-04	lb/MMscf	2.8E-06	1.38E-09	1.20E-05	lb/MMscf	1.8E-07	9.05E-11
T-526	0.00242	MMscfh	12,338	11,000	1.0	0.33					0.068	lb/MMBtu	0.7	0.00	see below[2]		1.5	0.00	1.9	lb/MMscf	0.02	0.00	7.6	lb/MMscf	0.07	0.00	0.37	lb/MMBtu	3.7	0.00	5.0E-04	lb/MMscf	4.9E-06	2.44E-09	1.84E-04	lb/MMscf	1.8E-06	8.94E-10	1.20E-05	lb/MMscf	1.2E-07	5.84E-11
T-530	0.00638	MMscfh	9,880	7,000	1.0	0.33					0.068	lb/MMBtu	1.4	0.00	see below[2]		2.5	0.00	1.9	lb/MMscf	0.04	0.00	7.6	lb/MMscf	0.16	0.00	0.37	lb/MMBtu	7.8	0.00	5.0E-04	lb/MMscf	1.0E-05	5.15E-09	1.84E-04	lb/MMscf	3.8E-06	1.89E-09	1.20E-05	lb/MMscf	2.5E-07	1.24E-10

	VOC[3]		NO_X		SO_2		PM		$PM_{10}/PM_{2.5}$		CO		Pb		Hg		Be	
Total Projected Actual Emissions				4.4E-03		0.01		1.2E-04		4.8E-04		0.02		3.1E-08		1.2E-08		7.6E-10
Major New Source Review Thresholds		40		40		40		25		15		100		0.6		0.1		0.1
Major New Source Review Triggered?		No		No		No		No		No		No		No		No		No

[1] Event emission rate represents one worst case emergency/malfunction scenario event. Annual emission rate represents the estimated annual average total duration of worst case emergency/malfunction events.

[2] SO_2 Emissions Calculation:

SO2 MW (lb/lb-mole)=		64

SO2 emissions are calculated based on the concentration of sulfur in the gas stream, the ideal gas law, and the molecular weight of SO2.

General Assumptions Used in Calculations

Variable	Value	Units
V	1,000,000	ft^3
P	14.7	psia
R	10.73	psia-ft^3/lbmol-R
T	527.7	R
md	2596.15	lbmols/MMscf
	385.1851	scf/lbmol

Ideal Gas Law used to determine the moles of gas per MSCF (P*V=n*R*T)

[3] Note that VOC emissions will actually decrease with respect to the current scenario where releases are not vented to the Flare since they will be controlled by the Flare; therefore, the potential VOC emissions associated with emergencies and malfunctions will decrease. Refer to the application text for more information.

Other Notes:

- Natural gas Higher Heating Value (Btu/scf) = 1020
- The VRU WARP project ties existing blowdown RVs to the VRU Flare header system from VRU 100 and VRU 200 and consists of emergency RVs only. Nitrogen will be used as the purge gas for the new header tie-ins.
- No modifications to the flare, flare knockout drum, or piping from the knockout drum to the flare required modifications to accommodate the worst case emergency relief scenarios when considering the worst case relief scenarios for the current operations
- Regulatory applicability for 40 CFR 63, Subpart CC will not change as a result of the project. Emergency RVs are not miscellaneous process vents per 40 CFR 63, Subpart CC since they are exempted from the definition in 40 CFR 63.641
- RV release gas combustion emission factors for PM/PM10/PM2.5, Lead, Beryllium and Mercury are from AP-42 Section 1.4 (July 1998). Emission factors for VOC, NOx, and CO are from AP-42 Section 13.5 (September 1991). The emissions for SO2 are calculated
- It was also conservatively assumed that each RV would lift one time per year, although this is an unlikely scenario.

Fugitive Emission Calculations for TK-3637

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	0	0.5789	0.0013	2.0%	0.0000	95%	100%	0.00
Light Liquid	10	0.1878	0.0037	2.0%	0.0738	95%	100%	0.02
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Light Liquid	22	0.0827	0.00013	0.3%	0.0083	30%	100%	0.03
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	0	3.728	0.0985	2.0%	0.0000	100%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
							Total VOC Emissions (tons/yr):	**0.04**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

Relief Valves are controlled

Reference Data

3SPS potential emissions are presented below only for reference for determining the particulate emissions from the SCR. The 3SPS boilers will not be modified for this project since the SCR will be an add-on control.

Process Unit	Maximum Heat Capacity		VOC				NOx				SO2				PM				PM10/PM2.5				CO				Pb			
			EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy
3SPS	2,774	MMBtu/hour									24.45	lb/MMscf	56.4	246.9																
Fired Heater	198	MMBtu/hour	5.5	lb/MMscf	1.1	4.7	0.05	lb/MMBtu	9.89	43.3	26.44	lb/MMscf	4.3	19.0	1.9	lb/MMscf	0.4	1.6	7.6	lb/MMscf	1.5	6.5	0.02	lb/MMBtu	4.0	17.3	5.0E-04	lb/MMscf	9.7E-05	4.2E-04

NOx emissions calculated above are pre-SCR, uncontrolled emissions.

Conversion Rate	3.0%
NOX Reduction (from inlet to SCR)	95%
NSPS J Limit (ppm)	159
TRS Reported in 2005 (ppm)	147
Calculated SO2 Emission Factor at NSPS J Limit (lb/MMscf)	26.44
Calculated SO2 Emission Factor at Current Maximum Average TRS (lb/MMscf)	24.45
Duct Burner ppm sulfur	159.00
Duct Burner SO2 Emission Factor (lb/MMscf)	26.44
Refinery Fuel Gas HHV (BTU/scf)	1203.33
3 SPS Boiler Utilization Factor	0.965

Project Potential to Emit Increase - for permitting level applicability

Conversion to Ammonium Sulfate

Control Device	SO_2 to SO_3 Conversion Rate		VOC				NOx				SO2				PM				PM10/PM2.5				CO				Pb				Sulfuric Acid Mist				Mercury				Beryllium			
			EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy
SCR Impact on Boilers	3.0%	% Conversion Rate	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					n/a	n/a	3.5	15.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Duct Burners	198	MMBtu/hour			1.1	4.7			9.9	43.3			4.3	19.0	1.9	lb/MMscf	0.4	1.6			1.7	7.6			4.0	17.3			0.0	0.0				0.9	1.8E-07	lb/MMBtu	3.6E-05	1.6E-04	1.2E-08	lb/MMBtu	2.3E-06	1.0E-05
Project PTE						4.7				43.3				19.0								22.9				17.3								0.9				1.6E-04				1.0E-05
Project PTE (with NOx controls included)						4.7				2.2				19.0								22.9				17.3																
Part 70 Minor						**2.7**				**4.6**				**10**								**5**				**25**																
Part 70 Significant						**25**				**25**				**25**								**25**				**100**																
Part 70 Permit Required?						**Yes**				**Yes**				**Yes**								**Yes**				**No**																

Project Emissions Increase - for major NSR applicability

Potential 3SPS Gas Usage Rate (based on maximum heat input capacity and utilization factor)	Potential SO2			
MMscf/year	EF	Unit	lb/hr	tpy
20,196.89	24.45	lb/MMscf	n/a	246.9
Potential Duct Burner SO2 Emissions	26.44	lb/MMscf	4.3	19.0
Total Potential SO2 Emissions				265.9

Conversion to Ammonium Sulfate

Control Device	SO_2 to SO_3 Conversion Rate		VOC				NOx				SO2				PM				PM10/PM2.5				CO				Pb				Sulfuric Acid Mist				Mercury				Beryllium			
			EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy	EF	Unit	lb/hr	tpy
SCR Impact on Boilers	3.0%	% Conversion Rate	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					n/a	n/a	n/a	15.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Duct Burners	198	MMBtu/hour				4.7				2.2				19.0	1.9	lb/MMscf	0.4	1.6				7.6				17.3				0.0	n/a	n/a	n/a	0.87	1.8E-07	lb/MMBtu	3.6E-05	1.6E-04	1.2E-08	lb/MMBtu	2.3E-06	1.0E-05
Project Emissions Increase						4.7				2.2				19.0				1.6				22.9				17.3				4.2E-04				0.9				1.6E-04				1.0E-05
Duct Burner and SCR Baseline Emissions						-				-				-				-				-				-				-				-				-				-
Project Emission Increase (Potential - Baseline)						4.7				2.2				19.0				1.6				22.9				17.3				4.25E-04				0.9				1.6E-04				1.0E-05

Assumptions:

- Maximum Heat Input Capacity = 575 MMBtu/hr *5 Boilers *96.5% availability at 3SPS
- Projected actual gas usage rates are based on assuming 8,760 hours of operation at the maximum permitted capacity.
- No credit is currently taken for NOx reductions from the boilers.
- Post -SCR NOx emissions are based on vendor guarantee emission rates using SCR technology.
- Since the duct burners are new units, PTE is used for the projected actual emissions.
- SO2 emissions are calculated using Refinery fuel gas HHV before the CXHO project and the Ideal Gas Law
- Fuel Gas Heating Value = 1203.3 BTU/scf
- Natural Gas Heating Value = 1020 BTU/scf

-Ammonium Sulfate Molecular Weight = 132.14
-Sulfur Trioxide Molecular Weight = 80.06
- Sulfur Dioxide Molecular Weight = 64.06
- Sulfuric Acid Mist Molecular Weight = 98.07
- BP is conservatively considering that all of the SO_3 emitted can form both condensable particulate matter and sulfuric acid mist.
- Fraction of SO_3 converted to Sulfuric Acid Mist = 1
- Moles in 1 MMscf (n from Ideal Gas Law) (lbmol/MMscf) 2596.15 *Derived from the Ideal Gas Law, assuming V = 1MMscf, P = 14.7 psia, T = 527.7 R, R = 10.73 psia-ft^3/lbmol-R*

Fugitive Emission Calculations for New Boilers

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	126	0.5789	0.0013	2.0%	1.6194	95%	100%	0.35
Light Liquid	0	0.1878	0.0037	2.0%	0.0000	95%	100%	0.00
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	76	0.0827	0.00013	0.3%	0.0287	30%	100%	0.09
Light Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	3	3.728	0.0985	2.0%	0.5133	100%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	1	0.0827	0.00013	2.0%	0.0018	0%	100%	0.01
							Total VOC Emissions (tons/yr):	**0.45**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

Relief Valves are controlled

Fugitive Emission Calculations for Fuel Gas Lines for 3 SPS SCR Duct Burners

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	150	0.5789	0.0013	2.0%	1.9278	95%	100%	0.42
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	255	0.0827	0.00013	0.3%	0.0963	30%	100%	0.30
Light Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Heavy Liquid	0	0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	0	3.728	0.0985	2.0%	0.0000	100%	100%	0.00
Open-ended Lines	10	0.02635	0.0033	2.0%	0.0376	0%	100%	0.16
Sampling Connections	0	0.0827	0.00013	2.0%	0.0000	0%	100%	0.00
							Total VOC Emissions (tons/yr):	**0.88**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500//10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

1131 Required Boiler Heat Input (MMBTU/hr)* (2 boilers at 580 MMBtu/hr each at 97.5% total annual utilization)

8760 Hours of Operation

Conservative Emissions Case

Pollutant	Emission Factor** (lb/MMBtu)	Emissions (lb/hr)	Emissions (tpy)
NOx	0.065	73.5	322.0
SO2	***	20.0	49.8
PM	0.002	2.1	9.2
PM10/PM 2.5	0.007	9.7	40.0
CO	0.024	27.1	118.9
VOC	0.005	6.1	26.7
Sulfuric Acid Mist	5.E-04	0.5	2.3
Lead	4.9.E-07	6.E-04	2.E-03
Mercury	1.8E-07	2.E-04	9.E-04
Berylllium	1.18E-08	1.E-05	6.E-05

0.065 NOx (lb/MMBtu)
0.007 PM10/PM2.5 (lb/MMBtu)
0.024 CO (lb/MMBtu)
0.005 VOC (lb/MMBtu)

3% % Conversion of SO2 to SO3

64.06 Molecular Weight of SO2
98.07 Molecular Weight of H2SO4

** EF Notes:

1) NOx factor based on manufacturer's guarantee (control technology/technique to be determined)

2) SO2 emissions will be limited to 24.9 tpy per boiler and emissions will be calculated based on total sulfur in refinery fuel gas. Natural gas blending will be used, if necessary.

3) PM based on AP-42 Table 1.4-2.

4) PM10/PM2.5 emission factor based on AP-42 Table 1.4-2 total particulate (condensible and filterable); Note that additional PM10/PM2.5 emissions were added, assuming that an SCR may be added to the boilers and 3% conversion of SO2 emissions to SO3 and ammonium sulfate.

5) CO based on manufacturer's guarantee.

6) Refinery fuel gas heating value assumed to be 1200 BTU/scf

7) VOC based on AP-42 Section 1.4 for natural gas

8) Lead, beryllium, and mercury emissions based on AP-42 Section 1.4 for natural gas.

9) Sulfuric Acid Mist emissions based on assumed conversion percentage of SO2 to SO3 and the assumption that all SO3 converts to sulfuric acid mist.

Refinery Fuel Gas HHV (BTU/scf)	1200
Natural Gas HHV (BTU/scf)	1020
Natural Gas SO2 Emission Factor (lb/MMscf)	0.6
Refinery Fuel Gas SO2 Emission Factor (at S ppm listed above) (lb/MMscf)	0.0

3 SPS Baseline for CO Reduction

F-factor	
8710	scf/mmbtu
7.27E-08	K-factor for CO
28	CO MW

CO and O2 Analyzer Data:

	%O2		CO (ppm)		MMSCF/yr		BTU/scf		MMBTU/yr		lb/MMBTU		CO (tpy)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	**2004**	**2005**
Boiler 31	9.36	8.45	27.24	90.9	2690.84	2749.28	1150.09	1279.182	3,094,708	3,516,834	0.031248	0.096657	48.3512	169.9629
Boiler 32	6.21	9.59	24.85	20.3	3213.87	2408.26	1150.09	1279.182	3,696,238	3,080,596	0.022404	0.023803	41.40467	36.66309
Boiler 33	5.88	7.46	39.91	30.4	3173.27	2616.82	1150.09	1279.182	3,649,546	3,347,394	0.035174	0.02995	64.18397	50.12744
Boiler 34	8.96	8.17	15.77	53.5	2748.05	2703.50	1150.09	1279.182	3,160,510	3,458,261	0.017484	0.055669	27.62978	96.25842
Boiler 36	6.79	7.71	57.16	60.5	3045.04	2718.25	1150.09	1279.182	3,502,070	3,477,131	0.053638	0.060762	93.92229	105.6381
TOTAL												**TOTAL**	**275.4919**	**458.6499**

boiler	31	32	33	34	36	Total
Averages 2004-2005	**109.16**	**39.03388**	**57.15571**	**61.94410002**	**99.78019**	367.07

Notes:

- %O2, ppm CO and MMSCF/yr are annual average values obtained from averaging monthly CEMS and analyzer data
- Note that this conservatively uses CO analyzer data instead of the data reported in the TRI/I-Steps based on the emission factor.

Potential to Emit for 3 SPS Boilers Based on Vendor Guaranteed Emission Factor and Limited Utilization Factor of 96.5%

Process Unit	Maximum Heat Capacity		CO				
			EF	Unit	lb/hr	tpy	
3SPS 1	555	MMBtu/hour	0.02	lb/MMBtu	11.1	48.6	per boiler
3SPS 2	555	MMBtu/hour	0.02	lb/MMBtu	11.1	48.6	
3SPS 3	555	MMBtu/hour	0.02	lb/MMBtu	11.1	48.6	
3SPS 4	555	MMBtu/hour	0.02	lb/MMBtu	11.1	48.6	
3SPS 6	555	MMBtu/hour	0.02	lb/MMBtu	11.1	48.6	

CO Emission Factor is based on vendor guarantee.

CO Emissions Reductions from 3 SPS Boilers

Boiler	CO tpy	
1	(60.5)	*Future Potential CO Emissions - Past Actual CO Emissions*
2	9.6	
3	(8.5)	
4	(13.3)	
6	(51.2)	
Total	**(124.0)**	*Total CO Reduction*

Tank 8

Tank 8 is an oil/water separator that currently handles the wastewater associated with the 11 Pipe Stills. This is a new oil/water separator system that may eventually replace Tank 8; however, both may operate for a period of time.

Estimated New Fugitive Components Associated with the Tank 8 Oil/Water Separator System

Component Type	# of components
Valves	
Gas/Vapor	15
Light Liquid	15
Heavy Liquid	50
Pumps	
Light Liquid	
Heavy Liquid	15
Flanges	
Gas/Vapor	20
Light Liquid	20
Heavy Liquid	40
Compressors	0
Relief Valves	5
Open-ended Lines	0
Sampling Connections	8

New Tank 8 Oil/Water Separator System

Maximum average daily estimated flow rate of material through the new Tank 8 oil/water separator (gal/day)	100,000	*Based on design estimates*
VOC Emission Factor (lb/kgal)	0.2	*Covered Oil/Water Separator from AP-42 Table 5.1-2 (1/95)*
VOC Emissions (lbs/day)	20	*Maximum average daily flow rate * VOC Emission Factor*
VOC Emissions (tpy)	3.7	*VOC Emissions lbs/day * 365 days /yr * 1 ton/2,000 lbs*

Note that the oil/water separator will be subject to the requirements of 40 CFR 61, Subpart FF and will be equipped with carbon canisters to control emissions.

Note that a new junction box and new manhole and sewer drain may be installed, depending on the final location chosen within the refinery.

Fugitive Emission Calculations for Tank 8 OWS Replacement

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	15	0.5789	0.0013	2.0%	0.1928	95%	100%	0.04
Light Liquid	15	0.1878	0.0037	2.0%	0.1107	95%	100%	0.02
Heavy Liquid	50	0.00051	0.00051	2.0%	0.0255	30%	100%	0.08
Pumps								
Light Liquid	0	0.9630	0.0265	2.0%	0.0000	80%	100%	0.00
Heavy Liquid	15	0.8565	0.02976	2.0%	0.6944	30%	100%	2.13
Flanges								
Gas/Vapor	20	0.0827	0.00013	0.3%	0.0076	30%	100%	0.02
Light Liquid	20	0.0827	0.00013	0.3%	0.0076	30%	100%	0.02
Heavy Liquid	40	0.0827	0.00013	0.3%	0.0151	30%	100%	0.05
Compressors	0	3.545	0.1971	2.0%	0.0000	0%	100%	0.00
Relief Valves	5	3.728	0.0985	2.0%	0.8555	100%	100%	0.00
Open-ended Lines	0	0.02635	0.0033	2.0%	0.0000	0%	100%	0.00
Sampling Connections	8	0.0827	0.00013	2.0%	0.0143	0%	100%	0.06
							Total VOC Emissions (tons/yr):	**2.43**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500/10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).

Relief Valves are controlled

Diesel Fire Pump Engines Emissions

There are three identical diesel fire pump engines

Hours of Operation	500	*Emergency fire pump engines used for the fire water system*
Number of Engines	3	
Engine HP	390	*Actual mechanical HP estimated based on the mechanical effciency, assumed 0.9*
Load Factor	100%	*Conservatively assumes that pump engine is operated at 100% load, actual load depends on operating point of engine/pump combination*

		NO_x		CO		$PM/PM_{10}/PM_{2.5}$		SO_x		VOC
		AP-42	NSPS IIII	AP-42	NSPS IIII	AP-42	NSPS IIII	AP-42	Low Sulfur Diesel	AP-42
Emission Factor (lb/hp*hr)		0.031		0.00668		0.0022		0.00205		0.00251
Emission Factor (g/hp*hr)		14.0616	**7.8**	3.030048	**2.6**	0.99792	**0.4**	0.92988	**0.161**	1.138536
Emission Factor (g/kw*hr)		18.848	**10.5**	4.06144	**3.5**	1.3376	**0.54**	1.2464		1.52608
Emissions (lb/hr)	each engine	6.71		2.24		0.34		0.14		0.98
Emissions (tpy)	each engine	1.68		0.56		0.09		0.03		0.24
Total Emissions (lb/hr)		20.12		6.71		1.03		0.42		2.94
Total Emissions (tpy)		5.03		1.68		0.26		0.10		0.73

Notes

Emission factors are from AP-42 Section 3.3, Table 3.3-1 (10/96) and NSPS Subpart IIII.

VOC emission factor is the sum of the TOC emission factors for exhaust and crankcase.

PM is assumed to be equal to PM_{10} for the purposes of these calculations. It should be noted that AP-42 Section 3.3 does not include a PM emission factor, and footnote b of Table 3.3-1 indicates that all particulate is assumed to be less than 1 micrometer.

Emission factors noted in red are emission standards for engine 300~600 HP, per 40 CFR 60, Subpart IIII

Emission estimates are based on the lower of AP-42 emission factors and Subpart IIII emission limits

40 CFR Subpart IIII limits NOx + NMHC. NOx assumed emitted at Subpart IIII limit and VOC emitted at AP-42 factor levels.

SO2 emission factor based on NSPS limit of 500 ppm fuel sulfur content and calculations below.

Sample Calculation

NOx emissions from compressor (lb/hr) = $\frac{390\ \text{hp} \times 7.8\ \text{g NOx/hp-hr} \times 1\ \text{lb}/453.6\ \text{g} \times 100\% \times 3\ \text{engines}}{} = 20.12\ \text{lb NOx/hr}$

SO2 emission factor calculation: $\frac{0.0005\ \text{lb S}}{\text{lb diesel}} \times \frac{7.1\ \text{lb diesel}}{\text{gal diesel}} \times \frac{\text{gal diesel}}{.140\ \text{MMBtu}} \times \frac{2\ \text{lb SO2}}{\text{lb S}} \times \frac{7000\ \text{MMBtu}}{10\text{^}6\ \text{hp-hr}} \times \frac{453.6\ \text{g}}{\text{lb}} = 0.161\text{g SO2/hp-hr}$

Conversion factors found in AP-42 Table 3.3-1 were used above to calculate engine fuel efficiency in MMBtu/hp-hr

Summary of Dewatering and Thermal Desorption System Project
Emission Calculations

	VOC (tons/yr)	NOx (tons/yr)	PM (tons/yr)	PM10/PM2.5 (tons/yr)	CO (tons/yr)	SO2 (tons/yr)
Dewatering Emissions	0.9	n/a	n/a	n/a	n/a	n/a
Thermal Desorption Emissions (Burners and VOC)	1.0	5.2	0.5	0.8	1.3	1.8
Fugitive Equipment Components	0.6	n/a	n/a	n/a	n/a	n/a
TOTAL	2.4	5.2	0.5	0.8	1.3	1.8
PERMITTING STATUS	**EXEMPT**	**PERMIT REQUIRED**	**EXEMPT**	**EXEMPT**	**EXEMPT**	**EXEMPT**
Permitting Thresholds:						
Part 70 Minor Source Mod	2.7	4.6	5	5	25	10
Part 70 Significant Source Mod	25	25	25	25	100	25

Potential Emissions Calculations for Dewatering System

Refer to the application text for a description of the dewatering system.

Mass Balance Emissions Calculation

Maximum values from sludge analytical data from 2000 to 2002 documented in Hazardous Waste Combustor MACT Performance Test Plans

		DAF Float/Biosolids	API Sludge
Method 8270 (SVOCs)		mg/kg	mg/kg
Anthracene		9.9	ND
Chyrsene		16.5	ND
Naphthalene		149	47
Phenanthrene		97.7	33
Pyrene		30.95	33
	Total SVOCs	**304.05**	**113**
Method 8260 (VOC)			
Benzene		110	20
Ethylbenzene		245	48
Toluene		530	66.5
Xylenes		700	180
	Total VOC	**1585**	**314.5**

Dewatering System Capacity

Density of Water (lb/gal)		8.34
Conversion Factor (lb/g)	0.0022	
Conversion Factor (mg/g)	1000	
Conversion Factor (g/kg)	1000	
Total SVOCs (lb/lb)	0.00030405	
Total VOCs in Feed (lb/lb)	0.001585	
Potential SVOC and VOC throughput (lb/lb)	0.00188905	*Sum of SVOCs and VOCs in feed*
VOC Control Efficiency (%)	95%	*Based on 40 CFR 61, Subpart FF requirements; Note that carbon actually provides a 99.9% control efficiency if monitored for breakthrough and changed after breakthrough is detected (per carbon system vendors); however, 95% used as a conservative measure in accordance with regulatory requirements.*
Thermal Desorption System Feed Rate Capacity (tons feed/year)	22500	*Based on system design (range of 18,000 to 20,000, depending on solids percentage of feed)*
Concentration Ratio of Dewatering system	4	*Typical design solids concentration ratio of sludge processed in dewatering system (pre to post dewatering system)*
Dewatering System Feed Rate Capacity (tons feed/year)	90000	*Based on system design of thermal desorption system * concentration ratio of dewatering system (range of 18,000 to 20,000, depending on solids percentage of feed)*
Percentage of Volatile Material Processed Emitted at Dewatering (%)	10%	*Engineering estimate based on relative non-volatility of material remaining in sludges after processing steps prior to dewatering system. Note that most of the oil will be recovered in the dewatering and thermal desorption system.*
Potential Uncontrolled SVOC and VOC emissions (tpy)	17.00	
Potential Controlled SVOC and VOC emissions (tpy)	**0.85**	

Thermal Desorption System

The thermal desorption system is a closed system with the exception of vents for the processed solids system, the noncondensible stream that is vented to the system burners, and the burner emissions. Refer to the application for a detailed description.

Waste Stream Composition Estimates

Solids (% by weight from the dewatering system)	40%	*Based on conservative typical design estimates*
Water (% by weight from dewatering system)	40%	*Based on conservative typical design estimates*
Oil (% by weight from dewatering system)	20%	*Based on conservative typical design estimates*

System Capacity Information

System Oil Recovery Estimate (% by weight)	80%	*Based on conservative design estimates - 90% recovery is typically expected*
Noncondensible Portion Estimate (% by weight)	20%	*Based on conservative design estimates - 10% noncondensibles are typically expected*
System Production Capacity (dry tons solids produced/year)	9000	*Based on system design*
System Feed Rate Capacity (tons feed/year)	22500	*Based on system design (range of 18,000 to 22,500, depending on solids percentage of feed)*

Noncondensible Hydrocarbons Routed to Burner

Assumes that negligible amounts of organic material will be left in recovered solids after thermal desorption and that all the material that is not recovered is included in the noncondensibles portion. Note that the noncondensible portion will consist of hydrocarbons that do not condense at above 150 to 160 degrees F such as methanes and propanes.

Oil in Feed (tpy)	4500	*Percent by weight oil in feed * System Feed Rate Capacity*
Noncondensible Portion of Oil in Feed (tpy)	900	*Percent by weight noncondensible portion * Oil in Feed*
VOC Control Efficiency (%)	99.9%	*Based on vendor tests for other applications of the thermal desorption system*
Potential VOC Emissions (tpy)	0.9	*Noncondensible Portion of Oil in Feed * (1-VOC Control Efficiency)*

Based on the previous experience of the vendor with other waste streams that contain sulfur compounds, hydrogen sulfide in the stream from the thermal desorption unit is typically absorbed in the condensed oil and elemental sulfur typically remains in the solids. The sulfur emissions from the fuel burned in the burner typically are greater than those from the supplemental noncondensible stream.

Processed Solids System

It is presumed that negligible amounts of VOC will be emitted from the recovered solids since they have been processed through the thermal desorption system. In addition, the recovered solids system will be enclosed for the rehydration process and routed to a wet scrubber. Therefore, the controlled emissions are presumed to be neglible.

Diesel Fired Burner Emissions

The thermal desorption system is equipped with two burners that burn distillate fuel. In addition, the noncondensible vapor stream is routed through the burners for destruction of the lighter hydrocarbons that are not recovered in the oil. Note that the noncondensible portion will consist of hydrocarbons that do not condense at above 150 to 160 degrees F such as methanes and propanes.

Distillate Firing Emissions:

Hours of Operation	8760	
Burner Rating (MMBtu/hr)	8	*Total maximum rating of two burners*
Density of Diesel Fuel (lb/gal)	7.05	
Heating Value of Fuel (Btu/lb)	19,300	*From note in AP-42 section 3.3 below table 3.3-1*
Heating Value of Fuel (Btu/gal)	137,000	*From AP-42 Appendix A, Typical parameters of various fuels*
Fuel Consumed (lb/hr)	414.51	
Fuel Consumed (gal/hr)	59	
Fuel Consumed (gal/day)	1411	*Based on maximum burner capacity; Note that 750 to 1000 gallons per day is the expected usage rate*
Fuel Sulfur %	0.05	*As required by 40 CFR 80.29(a)(1) - distillate produced by BP Whiting*

Criteria Pollutants

	NO_x	CO	SO_2	PM_{10} (Filterable)	$PM_{10}/PM_{2.5}$ (Filterable + Condensable)	VOC
AP-42 Emission Factor (lb/kgal)	20	5	7.1	2	3.3	0.2
Emissions (lb/hr)	1.18	0.29	0.42	0.12	0.19	0.01
Emissions (tpy)	5.15	1.29	1.83	0.52	0.85	0.05

Other Pollutants

	Lead	Mercury	Beryllium	Benzene*
AP-42 Emission Factor (lb/10^12 Btu)	9	3	3	2.14E-04
Emissions (lb/hr)	0.00	0.00	0.00	<0.01
Emissions (tpy)	0.00	0.00	0.00	<0.01

Notes

Emission Factors taken from AP-42 Section 1.3 tables 1.3-1, 1.3-2, 1.3-3 assuming boiler fired by No. 2 oil (9/98).

VOC emission factor is NMTOC factor from AP-42 Section 1.3-3 (9/98).

SO2 emission factor = 142 * Fuel Sulfur % (AP-42, Section 1.3, Table 1.3-1, 9/98).

PM_{10} emission factor is sum of filterable and condensable factors from Tables 1.3-1 and 1.3-2.

PM is assumed to be equal to filterable factor only for purposes of these calculations.

*Other pollutant emission factors are from Tables 1.3-9 and 1.3-10. The benzene emission factor is in lb/kgal.

The thermal desorption system will use the existing diesel tank associated with the FBI system. In addition, the thermal desorption system will use less fuel than the existing FBI system has used in the past; therefore, no increases associated with the tank are included.

Sample Calculation

$$\text{NOx Emissions (lb/hr)} = \frac{8\ \text{MMBtu}}{\text{hr}} \times \frac{1000000\ \text{Btu}}{\text{MMBtu}} \times \frac{\text{lb}}{19300\ \text{Btu}} \times \frac{\text{gal}}{7.05\ \text{lb}} \times \frac{\text{kgal}}{1000\ \text{gal}} \times \frac{20\ \text{lb}}{\text{kgal}} = 1.18\ \text{lb/hr}$$

Process Gas Stream Combustion Emissions:

Note that the distillate fuel use will be adjusted as the noncondensible portion provides heat input capacity such that the maximum rating of the burners will remain at 4 MMBtu/hr each. Therefore, the emissions calculated for the burners should account for all combustion emissions; however the emissions from the combustion of the vapors are calculated below for reference in determining if the emissions are higher when firing process gas in lieu of some of the diesel.

Potential VOC in Noncondensible Stream (tpy)	900	
Molar Volume (L/mol)	22.41	*Volume of 1 mole of gas, based on the ideal gas law equation at standard conditions*
SO2 Molar Weight	64.06	*lb/lb-mol or g/mol*
VOC Vapor Molar Weight (lb/lb-mole)	130	*Vapor molecular weight of distillate number 2 from TANKS 4.09d*
Conversion Factor (L/cf)	28.32	
Conversion Factor (lb/g)	0.0022	
Total VOC Routed to Burners (lb-mole/hr)	1.58	
Converted Molar Volume of gas (scf/lb-mol)	359.80	
Total Volume of Organic Vapors Combusted (MMscf/hr)	5.69E-04	*Based on the total VOC combusted per hour multiplied by the molar volume of the gas*
Total Volume of Vapors Combusted (MMscf/yr)	4.98E+00	*Based on the total VOC combusted per year multiplied by the molar volume of the gas*
Higher Heating Value of Refinery Fuel Gas (MMBtu/MMscf)	1200	*Conservatively assumes that the gas has a similar heating value to refinery fuel gas, although the heating value will vary.*
Higher Heating Value of Natural Gas (MMBtu/MMscf)	1020	*This is used to convert the natural gas emission factors per footnote a in Table 1.4-1 of AP-42 Section 1.4.*
Sulfur Concentration (ppm)	46.03	*Based on the average hydrogen sulfide content of the refinery fuel gas from 2003-2004. This conservatively assumes the same H2S concentration as refinery fuel gas; however, the H2S is not expected to be present in significant quantities in the noncondensible stream since it should be absorbed in the oil condensing phase.*

	NO_x	**CO**	**SO_2**	**$PM/PM_{10}/PM_{2.5}$**
Emission Factor based on Natural Gas (lb/MMscf)	100	84	see below	7.6
Burner Exhaust Emissions (lb/hr)	0.07	0.06	0.06	<0.01
Burner Exhaust Emissions (tpy)	0.29	0.25	0.28	0.02

Converted Flow Rate to Burners (MMscf/hr)	0.008	*Conservatively based on natural gas heat input and the maximum capacity of the burner*
SO2 Emission Rate (lb/hr)	0.06	
SO2 Emission Rate (tpy)	0.28	

The emissions associated with the diesel burners are higher than emissions when burning process gas; therefore, the diesel burner emissions will be used for potential emissions estimates.

Notes

Emissions factors for NO_X, CO, PM_{10} are from AP-42 Section 1.4 tables 1.4-1 and 1.4-2 (7/98) assuming combustion similar to natural gas.

PM is assumed to be equal to PM_{10} and $PM_{2.5}$ or the purposes of these calculations.

Molar volume for VOC and SO2 calculated using ideal gas law at standard temperature and pressure.

These calculations are conservative as the noncondensible stream is not likely to contain as much hydrogen sulfide as the refinery fuel gas.

Note that it is presumed that the sulfur compounds in the noncondensible stream will mostly be H2S. Other reduced sulfur compounds that could be formed in the thermal desorption unit have similar boiling points to the hydrocarbons that are condensed and recovered, and these other sulfur compounds are expected to condense in the oil phase with the hydrocarbons.

Fugitive Emission Factors

Equipment/Service	EPA Refinery Average Emission Factors Kg/hr/source	EPA Refinery Average Emission Factors lbs/hr/source	EPA Refinery SCREENING Emission Factors - LEAK Kg/hr/source	EPA Refinery SCREENING Emission Factors - LEAK lbs/hr/source	EPA Refinery SCREENING Emission Factors - NO LEAK Kg/hr/source	EPA Refinery SCREENING Emission Factors - NO LEAK lbs/hr/source
Valves						
Gas/Vapor	0.0268	0.059083816	0.2626	0.5789	0.0006	0.0013
Light Liquid	0.0109	0.024030358	0.0852	0.1878	0.0017	0.0037
Heavy Liquid	0.00023	0.000507063	0.00023	0.00051	0.00023	0.00051
Pumps						
Light Liquid	0.114	0.25132668	0.437	0.963	0.012	0.0265
Heavy Liquid	0.021	0.04629702	0.3885	0.8565	0.0135	0.02976
Flanges						
Gas/Vapor	0.00025	0.00055	0.0375	0.0827	0.00006	0.00013
Light Liquid	0.00025	0.00055	0.0375	0.0827	0.00006	0.00013
Heavy Liquid	0.00025	0.00055	0.0375	0.0827	0.00006	0.00013
Compressors	0.636	1.40214	1.608	3.545	0.0894	0.1971
Relief Valves	0.16	0.35274	1.691	3.728	0.0447	0.0985
Open-ended Lines	0.0023	0.00507	0.01195	0.02635	0.0015	0.0033
Sampling Connections	0.015	0.03307	0.0375	0.0827	0.00006	0.00013

Reference:

A Factors are taken from EPA Document EPA-453/R-95-017, Nov. 1995, Table 2-2, Page 2-13.

B Factors are taken from EPA Document EPA-453/R-95-017, Nov. 1995, Table 2-6, Page 2-20.

Fugitive Emission Calculations for Dewatering and Thermal Desorption System

It is conservatively assumed that the components are in light liquid or vapor service, although the components may be in heavy liquid service. Only the new components associated with the new portions of the sludge handling system are included here.

LDAR Program: Monitoring per Consent Decree[1];

Factor Type: Refinery Screening (EPA Emission Factors EPA-453/R-95-017, Table 2-6)

Annual Hours of Service: 8760

Component Type	Estimated Component Count	EPA 'Refinery Screening' Factors LEAK (lb/hr/component)	EPA 'Refinery Screening' Factors NO LEAK (lb/hr/component)	Percent Leak	Maximum Uncontrolled Emission Rate (lbs/hr)	LD&R Control Efficiency[2]	Percent in VOC Service	Total VOC Emissions (Tons/yr)
Valves								
Gas/Vapor	22	0.5789	0.0013	2.0%	0.2827	95%	100%	0.06
Light Liquid	20	0.1878	0.0037	2.0%	0.1476	95%	100%	0.03
Heavy Liquid	0	0.00051	0.00051	2.0%	0.0000	30%	100%	0.00
Pumps								
Light Liquid	10	0.9630	0.0265	2.0%	0.4523	80%	100%	0.40
Heavy Liquid	0	0.8565	0.02976	2.0%	0.0000	30%	100%	0.00
Flanges								
Gas/Vapor	48	0.0827	0.00013	0.3%	0.0181	30%	100%	0.06
Light Liquid	60	0.0827	0.00013	0.3%	0.0227	30%	100%	0.07
Heavy Liquid		0.0827	0.00013	0.3%	0.0000	30%	100%	0.00
Compressors	0	3.545	0.197	2.0%	0.0000	0%	100%	0.00
Relief Valves	10	3.728	0.099	2.0%	1.7109	100%	100%	0.00
Open-ended Lines	0	0.026	0.003	2.0%	0.0000	0%	100%	0.00
Sampling Connections	2	0.083	0.00013	2.0%	0.0036	0%	100%	0.02
							Total VOC Emissions (lbs/day):	**3.46**
							Total VOC Emissions (tons/yr):	**0.63**

[1] United States, et.al v. BP Exploration & Oil, et.al., Northern District of Indiana, Hammond Division, Civil Action No. 2:96 CV 095 RL

[2] LD&R control efficiency for pumps and valves in gas and light liquid service are 95% and 80%, respectively based on a 500 ppmv leak definition for valves and 2000 ppmv compared to the 10,000 leak definition basis for screening factors (i.e., (1-500//10,000 = 95%) and (1-2,000/10,000) = 80%)

AVO monitoring equivalent to 30% control is applied to all flanges and heavy liquid valves and pumps.

30% control estimate per TCEQ Guidance "Air Permit Technical Guidance for Chemical Sources: Equipment Leak Fugitives" (October 2000).